KANNUR UNIVERSITY

(Abstract)

FYIMP in Physical Science offered jointly by the Dept of Physics & Dept of Chemistry at SAT Campus, Payyannur- Scheme & Syllabus - Approved - Implemented w.e.f. the academic year 2024-'25 - Orders Issued

ACADEMIC C SECTION

ACAD C/ACAD C3/13507/2024 Dated: 05.09.2024

Read:-1. U.O. No.Acad C3/22488/2023 dtd.15.03.2024

2. U.O No. ACAD H/ACAD H3/4513/2024 dated 15/05/2024

3. Minutes of the meeting of the FYIMP Implementation Committee held on 01/04/2024

4. U.O of even number dated 15/06/2024

5. Minutes of the FYIMP Scrutiny Committee held on 18/06/2024

6. Emails received from the Heads/ Course Director of FYIMP offering Depts.

7. Minutes of the meeting of the Academic Council held on 25/06/2024

ORDER

1. As per paper read (1) above, the Regulations for the Five Year Integrated Master's Programme (FYIMP) in University Teaching Departments/Schools were implemented w.e.f. the academic year 2024-25.

2. Accordingly, Five Year Integrated Masters Programmes (FYIMP) viz, Physical Science, Computational Science, Clinical Psychology, Anthropological Sciences were commenced at various campuses of Kannur University during the academic year 2024-'25. Further, the ongoing Five Year Integrated Master of Physical Education and Sports and Five Year Integrated M.Com. programmes, come under the FYIMP pattern w.e.f. the academic year 2024-25.

3. As per paper read as (3) above, the meeting of the FYIMP Implementation Committee suggested the Heads / Course Directors of the Teaching Departments concerned to conduct a Workshop for finalizing the Syllabus of the FYIMP and to submit the same to the University for approval.

4. Accordingly, the Heads/ Course Directors submitted the Syllabi concerned.

5. Later on, as per the paper read as (4) above, an FYIMP Scrutiny Committee was constituted to scrutinize the Syllabi submitted by the Heads/ Course Directors of the FYIMP offering Departments.

6. The FYIMP Scrutiny Committee, scrutinized the FYIMP Syllabi submitted by the Heads/ Course Directors concerned. The FYIMP offering Heads/ Course Directors were informed to submit the final Draft of the Syllabi, after incorporating the Modifications/Corrections suggested by the FYIMP Scrutiny Committee, along with the Minutes of the Department Council, approving the Syllabus.

7. As per paper read (6) above, the Heads of the Depts/Course Directors, offering FYIMP submitted the final Draft Syllabi, seeking approval.

8. Subsequently, the same was placed before the meeting of the Academic Council held on 25/06/2024, for consideration.

9. The XXVIII meeting of the Academic Council, vide item No.III (12) (paper read as (7) above), approved the Syllabus of the FYIMP in Physical Science, along with other five FYIMPs, to be commenced at various Campuses of the University w.e.f. 2024-'25 academic year, in principle and permitted to publish the same, considering the urgency of the matter.

10. The Minutes of the Academic Council was approved by the Vice Chancellor and published.

11. Therefore, the approved Syllabus of FYIMP in Physical Science, offered jointly by the Dept of Physics & Dept of Chemistry, at SAT Campus, Payyannur is attached with this UO and uploaded in the website of the University (www.kannuruniversity.ac.in).

Orders are issued accordingly.

Sd/-
ANIL CHANDRAN R
DEPUTY REGISTRAR (ACADEMIC)
For REGISTRAR

To: 1. Head, Dept of Physics
2. Head, Dept of Chemistry
3. Nodal Officer , FYIMP

Copy To: 1. PA to CE (To circulate the same among the Sections concerned under Examination Branch)
2. JR (Eaxam)
3. EP IV/ EG I/ EXC I (Exam)
4. Web Manager (to publish in the website)
5. Computer Programmer
6. PS to VC/ PA to R
7. SF/DF/FC

Forwarded / By Order
SECTION OFFICER

KANNUR UNIVERSITY
കണ്ണൂർ സർവകലാശാല

FIVE YEAR INTEGRATED MASTERS PROGRAMME (FYIMP)

PHYSICAL SCIENCE

(PHYSICS/CHEMISTRY)

Syllabus

DEPARTMENT OF PHYSICS

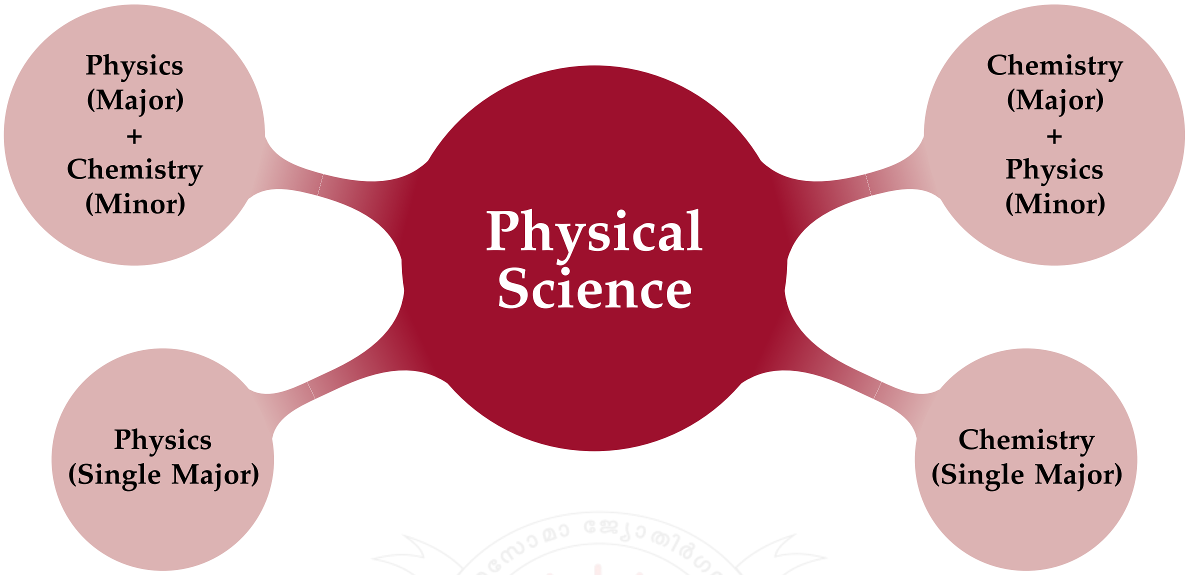
DEPARTMENT OF CHEMISTRY

Swami Anandatheertha Campus
Payyanur, Edat (PO)
Kannur - 670327
Kerala

2024

CONTENTS

Programme Pathways



The Five Year Year Integrated Masters Programme (FYIMP) in Physical Science of Kannur University spans ten semesters of student-centric teaching-learning process with a meticulously designed curriculum including both theory and practicum courses. The Programme structure ensures a strong foundation and in-depth knowledge in the subject for aspiring students while maintaining the essential flexibility in choosing the learning Pathway. The Two main Pathways are: Pathway - 1 offers a Major degree in Physics with optional Minor in Chemistry; For Pathway - 2, the Major degree will be in Chemistry with optional Minor in Physics.

Types of Courses

- **Discipline Specific Course (DSC)**: Discipline Specific Core should be pursued by a student as a mandatory requirement of his/ her programme of study.
- **Discipline Specific Elective (DSE)**: The Discipline Specific Electives are a pool of credit courses offered in the Major/Minor discipline from which a student will choose to study based on his/ her interest.
- **Ability Enhancement Course (AEC)**: AECs are part of the Foundation courses which offer knowledge enhancement through various areas of study. They are based on Language and Literature which are mandatory for all disciplines.
- **Skill Enhancement Course (SEC)**: SECs provide skill training and proficiency to students in various areas and courses may be chosen from a pool of courses offered by various departments.
- **Value Added Course (VAC)**: VACs are are offered by different disciplines and aimed towards personality building, embedding ethical, cultural and constitutional values and will help in all round development of students.
- **Multi Disciplinary Course (MDC)**: These are introductory-level courses in broad disciplines other than Physics/Chemistry. These courses are intended to broaden the intellectual experience and will be useful to understand society.

- **Internship**: internships in a firm, industry, or organization or Training in labs with faculty and researchers in the University or other higher education institutes.
- **Project/Dissertation**: Students can choose to take up research projects under the guidance of a faculty member. The research outcomes of their project work may be published in peer-reviewed journals or may be presented in conferences /seminars or may be patented.

Teaching/Assessment modes

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Programme Outcomes (POs)

Program Outcomes (POs) serve as a foundational framework defining the skills, knowledge, and attributes that students of Kannur University are expected to acquire upon completion of a specific academic program. Tailored to the unique goals of each program, POs articulate the overarching learning objectives that guide curriculum design and assessment. These outcomes encompass a diverse range of competencies, including critical thinking, problem-solving, effective communication, and discipline-specific expertise. POs play a crucial role in shaping educational experiences, ensuring alignment with academic standards and industry expectations. By articulating clear and measurable expectations, POs contribute to the continuous improvement of academic programs and provide a roadmap for students to develop into well-rounded, competent professionals within their chosen fields.

PO1	**Critical Thinking and Problem-Solving**-Apply critical thinking skills to analyze information and develop effective problem-solving strategies for tackling complex challenges.
PO2	**Effective Communication and Social Interaction**-Proficiently express ideas and engage in collaborative practices, fostering effective interpersonal connections.
PO3	**Holistic Understanding**-Demonstrate a multidisciplinary approach by integrating knowledge across various domains for a comprehensive understanding of complex issues.
PO4	**Citizenship and Leadership**-Exhibit a sense of responsibility, actively contribute to the community, and showcase leadership qualities to shape a just and inclusive society.
PO5	**Global Perspective**-Develop a broad awareness of global issues and an understanding of diverse perspectives, preparing for active participation in a globalized world.
PO6	**Ethics, Integrity and Environmental Sustainability**-Uphold high ethical standards in academic and professional endeavors, demonstrating integrity and ethical decision-making. Also acquire an understanding of environmental issues and sustainable practices, promoting responsibility towards ecological well-being.
PO7	**Lifelong Learning and Adaptability**-Cultivate a commitment to continuous self-directed learning, adapting to evolving challenges, and acquiring knowledge throughout life.

Programme Specific Outcomes (PSOs)

PSO1	Use concepts and principles in physical/chemical sciences with specific emphasis on fundamental laws and basic concepts to cater to the real-world problems.
PSO2	Apply mathematical/experimental techniques to solve and interpret the results of various physical/chemical systems.
PSO3	Illustrate the methodology required for the execution of physical/chemical experiments and analyze the experimental results with the corresponding interpretations.
PSO4	Develop communication skills to explain the basic concepts to both specialized and non-specialized audiences.

Course Structure: Physics

Type	Course	Code	Credit	Level
SEMESTER - I				
DSC	Core Concepts in Physics (A-1)	KU01DSCPHY101	4	100
	B-1		4	
	C-1		4	
AEC	Language (AEC-1)		3	
	Language (AEC-2)		3	
MDC	MDC -1		3	
Minimum Credit Requirement for SEMESTER I			**21**	
SEMESTER - II				
DSC	Electricity & Magnetism (A-2)	KU02DSCPHY101	4	100
	Mechanics (A-3)	KU02DSCPHY102	4	
	B/C-2		4	
	B/C-3		4	
AEC	Language (AEC-3)		3	
MDC	MDC-2		3	
Minimum Credit Requirement for SEMESTER II			**22**	
SEMESTER - III				
DSC	Fundamentals of Optics (A-4)	KU03DSCPHY201	4	200
	Basic Electronics (A-5)	KU03DSCPHY202	4	
	Quantum Physics: Basics (A-6)	KU03DSCPHY203	4	
	Introduction to Solid State Physics (A-7)	KU03DSCPHY204	4	
MDC	Kerala Studies (MDC-3)		3	
VAC	VAC-1		3	
Minimum Credit Requirement for SEMESTER III			**22**	
SEMESTER - IV				
DSC	Electromagnetic Theory-I (A-8)	KU04DSCPHY201	4	200
	Thermodynamics (A-9)	KU04DSCPHY202	4	
	Introduction to Astrophysics (A-10)	KU04DSCPHY203	4	
	Introduction to Nuclear & Particle Physics (A-11)	KU04DSCPHY204	4	
SEC	SEC-1		3	
VAC	VAC-2		3	
Internship	Internship (Vacation)	KU04INTPHY201	2	
Minimum Credit Requirement for SEMESTER IV			**24**	
SEMESTER - V				
DSC	Mathematical Physics I (A-12)	KU05DSCPHY301	4	300
	Electromagnetic Theory-II (A-13)	KU05DSCPHY302	4	
	Quantum Physics: Applications (A-14)	KU05DSCPHY303	4	
	Numerical Methods in Physics (A-15)	KU05DSCPHY304	4	
DSE (Minimum 1)	Biophysics	KU05DSEPHY301	4	
	Python Programming	KU05DSEPHY302		
SEC	SEC-2		3	
Minimum Credit Requirement for SEMESTER V			**23**	

Course Structure: Physics

Type	Course	Code	Credit	Level
SEMESTER - VI				
DSC	Classical Mechanics (A-16)	KU06DSCPHY301	4	300
	Advanced Electronics (A-17)	KU06DSCPHY302	4	
	Modern Optics (A-18)	KU06DSCPHY303	4	
DSE (Minimum 1)	Introduction to Nanomaterials	KU06DSEPHY301	4	
	Energy Physics	KU06DSEPHY302		
SEC	SEC-3		3	
Internship	Internship (Vacation)	KU06INTPHY301	2	
Minimum Credit Requirement for SEMESTER VI			**21**	
Students exiting after 3rd Year: awarded UG Degree with Major in Physics				
Total Credit Requirement for UG Degree			**133**	
SEMESTER - VII				
DSC	Quantum Mechanics (A-19)	KU07DSCPHY401	4	400
	Mathematical Physics II (A-20)	KU07DSCPHY402	4	
	Statistical Mechanics (A-21)	KU07DSCPHY403	4	
DSE (Minimum 2)	Photovoltaic Energy Conversion	KU07DSEPHY401	4+4	
	Fiber Optics	KU07DSEPHY402		
	Thin Film Technology	KU07DSEPHY403		
	Semiconducting Materials & Devices	KU07DSEPHY404		
MOOC	MOOC/Online Course		4	
Minimum Credit Requirement for SEMESTER VII			**24**	
SEMESTER - VIII				
DSC	Research Methodology (A22)	KU08DSCPHY401	4	400
MOOC	MOOC/Online Course		4	
Project	For **Honours with Research**		12	
	Research Project	KU08RPHPHY401		
DSC* (in lieu of Project*)	For **Honours** – three 4C Courses in lieu of Project*			
	Advanced Quantum Mechanics (A-23)	KU08DSCPHY402		
	Condensed Matter Physics (A=24)	KU08DSCPHY403		
	Nuclear Physics (A-25)	KU08DSCPHY404		
Minimum Credit Requirement for SEMESTER VIII			**20**	
Student Exit After Four Year: Hons/Hons with Research Degree with Major in Physics				
Total Credit Requirement for Hons/Hons with Research			**177**	
SEMESTER - IX				
DSC	Atomic & Molecular Physics (A-26)	KU09DSCPHY501	4	500
	Nanophotonics (A-27)	KU09DSCPHY502	4	
	Quantum Field Theory (A-28)	KU09DSCPHY503	4	
	Particle Physics & Astrophysics (A-29)	KU09DSCPHY504	4	
	General Theory of Relativity (A-30*)	KU09DSCPHY505	4	
	Optional*: One MOOC/Online/blended course in lieu of one DSC			
Minimum Credit Requirement for SEMESTER IX			**20**	
SEMESTER - X				
Research	Dissertation 20 Credits	KU10RPHPHY501	20	500
Minimum Credit Requirement for SEMESTER X			**20**	
After Five Year: Integrated Post Graduate Degree in Physics				
Total Credit Requirement for Post Graduate Degree			**217**	

DEPARTMENT OF PHYSICS

CORE COURSES

Semester - I

Core Concepts in Physics

Course Title	:	Core Concepts in Physics
Semester	:	01
Course Code	:	KU01DSCPHY101
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Higher secondary level Physics

Course Description:

- Introduce the basic concepts in Physics.
- Introduce dimensional analysis and equations of motion.
- Explain the concepts of Work & Energy
- Illustrate the basic idea of conservation of a physical quantity.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	1	4	3	2	5	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Recall Newton's laws of motion and describe the basic concepts related to objects in motion	R, U
2	Understand the basic concepts of Work, Energy, & Power	U, A
3	Understand linear momentum and apply it's conservation law in problems related to objects in motion	U, A
4	Understand & apply conservation of angular momentum and the concept of moment of inertia	U, A

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	2	-	-	1	-	2	-	-	-	1
CO2	3	2	-	-	1	-	2	-	-	-	1
CO3	3	2	-	-	1	-	2	-	-	-	1
CO4	3	2	-	-	1	-	2	-	-	-	1

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (12 Hours): Newton's Laws of motion
What is physics; Concepts, models and theories; Dimensional analysis; Vectors, displacement and velocity; Instantaneous velocity, acceleration; Physiological effects of acceleration, Equations of motion, vertical free fall, terminal speed; Newton's Laws, applications of Newton's law, illustration of initial conditions; projectile motion; Historical notes: the geocentric theory verses the heliocentric theory.

Module II (9 Hours): Work & Energy
Force and mass, Work done by a constant and variable force; Integrating equation of motion; Work energy theorem in one and three dimensions; Power; Potential energy, Conservative forces, Potential energy functions; Conservation of mechanical energy, Non-conservative forces.

Module III (12 Hours): Linear Momentum
Conservation of linear momentum, elastic collision in one dimension; Elastic collision in three dimension, Impulse, comparison of linear momentum with kinetic energy, rocket propulsion, Historical note: Robert Goddard and early rocketry.

Module IV (12 Hours): Rigid body motion & Conservation of Angular momentum
Centre of mass; Moment of inertia, Torque; The parallel axis theorem; rotational dynamics of rigid body along a fixed axis, angular momentum; Conservation of angular momentum, Spin and orbital angular momentum; Gyroscopic motion; Special topics: twist and somersaults.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Practicals (30 Hours): At least 6 Experiments to be performed

1. Find the moment of inertia of a rod, disc, ring familiarization of Vernier calipers, screw gauge.
2. Helical spring- Spring constant.
3. Show that the period of oscillation of a simple pendulum is independent of the mass of the bob used.
4. Determination of moment of inertia of fly wheel.
5. Inclined plane - determine the downward force along an inclined plane.
6. Concurrent forces - parallelogram law verification.
7. Concurrent forces - determination of unknown mass.
8. Simulation experiments using ExpEYES-SEELAB/ Virtual lab/PhET simulations

Core Compulsory Readings

1. Benson Harris, University Physics (R/e), Wiley India (1996).
2. Sears & Zemansky's University Physics with Modern Physics (13/e), Hugh Young and

Roger Freedman, , Pearson (2012).

3. R. Resnick, D. Halliday and K. S. Krane, Physics Vol 1 (5/e), John Wiley (1991).
4. D. Kleppner and R. Kolenkow, An Introduction to Mechanics (1/e), McGraw Hill Inc USA (1973).
5. C. Kittel et.al., Mechanics Vol 1 (2/e), Berkeley Physics Course, Tata-McGraw Hill Ltd (2008).
6. Halliday & Resnick, Fundamentals of Physics (10/e), Jearl Walker, Wiley (2013).

Core Suggested Readings

1. A. P. French, Newtonian Mechanics (M.I.T. Introductory Physics Series), CBS (1987).

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Discuss the projectile motion
2. Discuss the conservative and non-conservative forces.
3. Explain the conservation of linear momentum.
4. Explain the concept of moment of inertia.

Semester - II

Electricity & Magnetism

Course Title	:	Electricity & Magnetism
Semester	:	02
Course Code	:	KU02DSCPHY101
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Higher secondary level Physics

Course Description:

- This course aims to explain the concept of electric field, electric potential, magnetic field and magnetic potentials.
- With the Principle of superposition and law of Gauss, electric field intensity calculations are performed.
- Determine Electric potential of charge distributions and hence specify electric field intensity.
- Basic properties of conductors and capacitors are explained.
- Calculate the magnetic fields due to currents using Biot-Savart and Ampere's laws.
- Compare Magnetostatics and Electrostatics and understand Diamagnets, Paramagnets and Ferro magnets.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	1	4	3	2	5	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Understand the fundamental concepts of electric field associated with static charge distributions	R, U
2	Understand the concepts of electric field, electric potential, and capacitors.	U, A
3	Learn the basics of current electricity and solve circuit element problems	U, An
4	Describe the idea of magnetic field associated with a current carrying conductor.	U, An

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	-	-	1	-	2	-	-	-	1
CO2	3	2	-	-	1	-	2	-	-	-	1
CO3	3	2	-	-	1	-	2	-	-	-	1
CO4	3	2	-	-	1	-	2	-	-	-	1

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (9 Hours): Electrostatics
Electric field - Coulomb's law, Gauss's law and applications, Potential difference - potential of a localised charge distributions - Electrostatic boundary conditions.

Module II (9 Hours): Work & Energy
Work and energy in electrostatics - Work done to move a charge - Energy of a point charge distribution - Energy of a continuous charge distribution - Electrostatic energy, Conductors - Induced charges - Surface charge and Force on a conductor - Capacitors.

Module III (15 Hours): Electric Currents
Electric current and current density, Electrical conductivity and Ohm's law, The physics of electrical conduction, Conduction in metals, Semiconductors, Circuits and circuit elements, Energy dissipation in current flow, Electromotive force and the voltaic cell, Networks with voltage sources, Variable currents in capacitors and resistors.

Module IV (12 Hours): Magnetostatics
Magnetic fields, Magnetic force, Lorentz law, Biot-Savart Law, Ampere's Law, Magnetization, Inductance, Inductance Circuit, Faraday's law of electromagnetic induction, Lenz's law, self-inductance, mutual inductance, Energy stored in the magnetic field.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Practicals (30 Hours): At least 6 Experiments to be performed

1. Potentiometer-Resistivity
2. Potentiometer - Calibration of low range voltmeter, high range voltmeter, & ammeter.
3. Potentiometer – EMF of a thermocouple
4. Circular coil- magnetization of a magnet
5. Circular coil-dipole moment
6. Circular coil - Variation of field with distance.
7. Searle's vibration magnetometer- ratio of magnetic dipole moments.
8. Box type vibration magnetometers.

9. Deflection magnetometer - Tan A, Tan B, positions - magnetic dipole moment.
10. To study the frequency response of a series RC circuit

Core Compulsory Readings

1. D. J. Griffith, Introduction to electromagnetic Theory (3/e)
2. Edward M. Purcell, Electricity and Magnetism (2/e), Berkeley Physics Course Vol. 2.
3. Resnick and Halliday, Physics Vol. II
4. Arthur F Kip, Electricity and magnetism

Core Suggested Readings

1. Hugh D Young and Roger A Freedman, Electricity and Magnetism

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. State and prove Gauss's law.
2. Calculate the energy of a point charge distribution.
3. Describe the process of electrical conduction in metals

Mechanics

Course Title	:	Mechanics
Semester	:	02
Course Code	:	KU02DSCPHY102
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Basics Physics

Course Description:

- This course will introduce the basic concepts of fluid mechanics and oscillations.
- Waves and Fourier analysis will be discussed.
- The concepts of central force problem will be discussed.
- This course will illustrate planetary motion using Kepler's laws.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	1	4	3	2	5	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Recall concepts like surface tension, viscosity and Pascal's law and understand the basics of fluid dynamics in detail	R, U
2	Understand the basic concepts of simple harmonic motion in oscillations	U, A
3	Learn wave motion from basics concepts and explore Fourier analysis in wave mechanics	U, An
4	Recall Newton's law of gravitation and understand planetary motion basics	R, U, A

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	2	-	-	1	-	2	-	-	-	1
CO2	3	2	-	-	1	-	2	-	-	-	1
CO3	3	2	-	-	1	-	2	-	-	-	1
CO4	3	2	-	-	1	-	2	-	-	-	1

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I: Fluid Mechanics (9 Hours)
Fluid statics, Pressure & density, Depth, and Pascal's Law; Hydraulic Lever; Buoyancy; Archimedes's principle; Surface Tension; Equation of continuity; Bernoulli's Equation and its applications; Viscosity, turbulence and chaotic flow.

Module II: Oscillations (12 Hours)
Simple harmonic motion (SHM), block spring system, energy in SHM pendulum, small oscillations, damped oscillations, energy, Q value, forced oscillations, Resonance, undamped and forced harmonic oscillator.

Module III: Waves (12 Hours)
Wave characteristics, superposition of waves, reflection and transmission, traveling waves, standing waves, Transverse waves in stretched strings; longitudinal waves, Resonant standing waves on a string, the wave equation, Fourier analysis, interference, nature of sound waves, Resonant standing sound waves, interference of sound waves, Doppler effect.

Module IV: Central force problem (12 Hours)
Newtons law of gravitation, gravitational potential, escape velocity, Kepler's laws of planetary motion, satellite orbits, Central force motion as a one-body problem, The energy equation and energy diagrams; Tides.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Practicals (30 Hours): At least 6 Experiments to be performed

1. Atwood Apparatus - to determine g.
2. Torsion pendulum- Moment of inertia of a disc and rigidity modulus (using two identical masses)
3. Compound pendulum- To find g and radius of gyration
4. Young's modulus using cantilever bending
5. Young's modulus of the material of bar - uniform bending using optic lever
6. Young's modulus of the material of bar -non uniform bending
7. Surface tension by capillary rise method
8. Coefficient of viscosity –Poiseuille's formula (by measuring radius of capillary tube using mercury)
9. Young's Modulus by Koenig's Method
10. Melde's Apparatus
11. Helmholtz resonator - determination of unknown frequency of a tuning fork.
12. Kundt's tube - to determine the velocity of sound.
13. Simulation experiments using ExpEYES-SEELAB/ Virtual lab/PhET simulations

Core Compulsory Readings

1. Sears & Zemansky's University Physics with Modern Physics (13/e), Hugh Young and Roger Freedman, Pearson.
2. R. Resnick, D. Halliday and K. S. Krane, Physics Vol 1 (5/e), John Wiley (1991).
3. Benson Harris, University Physics (R/e) , Wiley India.

Core Suggested Readings

1. D. Kleppner and R. Kolenkow, An Introduction to Mechanics, McGraw Hill Inc USA (1973).

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Explain Pascal's law
2. How to determine the viscosity of a given liquid?
3. Explain forced and damped oscillations.
4. Explain central force motion as a one-body problem.

Semester - III

Fundamentals of Optics

Course Title	:	Fundamentals of Optics
Semester	:	03
Course Code	:	KU03DSCPHY201
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Basics of Electricity & Magnetism

Course Description:

- This course will introduce the basics of geometrical optics.
- Explain the wave nature of light via waveoptics.
- Illustrate interference and diffraction.
- Introduce plane of polarization of light and associated effects.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	1	4	3	2	5	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Explain the fundamental laws of Optics and describe the applications of geometric optics	U
2	Learn and illustrate the wave nature of light through wave optics	U, A
3	Learn and illustrate the diffraction of light	U, A
4	Understand the importance of polarization of an electromagnetic wave and extend the understanding to nontrivial cases.	U, A , An

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	2	2	1	1	1	-	-	-	-	1
CO2	3	2	2	1	1	1	-	-	-	-	1
CO3	3	2	2	1	1	1	-	-	-	-	1
CO4	3	2	1	1	1	-	-	-	-	-	1

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (9 Hours)
Geometrical Optics: Rectilinear propagation of light; The refractive index; Optical path; Laws of reflection and refraction; Fermat's principle; Color dispersion.

Module II (12 Hours)
Wave Optics: Interference of light, principle of superposition, Huygens' Principle; Young's experiment; Conditions for maximum and minimum intensities, Coherent sources, Theory of interference fringes, Colours of thin films-interference due to reflected light, Interference due to transmitted light, Fringes produced by a wedge shaped thin film, Newton's Rings by reflected light, Determination of wave length of sodium light and Refractive index of a transparent liquid by Newton's rings.

Module III (12 Hours)
Diffraction: Fresnel and Fraunhofer diffraction - Fresnel's Explanation of Rectilinear Propagation of light- Zone plate, Diffraction at a straight edge, Fraunhofer Diffraction at a single slit, Plane Transmission Diffraction Grating, Resolving power of optical instruments; Dispersive power of a Grating, Determination of wavelength of light using Transmission Grating. Comparison between interference and Diffraction.

Module IV (12 Hours)
Polarization of light, Polarization by reflection, Pile of Plate, Law of Malus, Double Refraction, Huygen's theory of double refraction in uniaxial crystal, Nicol Prism, Theory of production of Elliptically and Circularly Polarised light, Quarter wave plates, Half wave plate, Production and detection of Plane, Circularly and Elliptically polarized light.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Practicals (30 Hours): At least 6 Experiments to be performed

1. Spectrometer – Refractive index of the material of a prism
2. Spectrometer – Dispersive power of a prism
3. Newton's Rings- wavelength of sodium light
4. Air Wedge - Diameter of a thin wire
5. Spectrometer - i-d curve
6. Spectrometer - i-i' curve
7. Spectrometer - Cauchy's constants assuming wavelengths
8. Spectrometer – Grating normal Incidence
9. To determine the wavelength of a laser source using diffraction of a single slit
10. To determine the wavelength of a laser source using diffraction of double slits
11. To determine angular spread of He-Ne laser using plane diffraction grating
12. Simulation experiments using ExpEYES-SEELAB/ Virtual lab/PhET simulations

Core Compulsory Readings

1. N. Subrahmanyam and B. Lal, A Textbook of Optics (R/e), S. Chand, (2012).
2. Jenkins & White, Fundamentals of Optics (4/e), McGraw-Hill (2001).
3. Ajoy Ghatak, Optics (6/e), McGraw-Hill (2017)

Core Suggested Readings

1. M. Born & E. Wolf, Principles of Optics, Cambridge University Press (1999)

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Discuss Fermat's principle.
2. Explain Young's double slit experiment.
3. Discuss coherence of a source.
4. Discuss Fresnel and Fraunhofer diffraction of light.

Basic Electronics

Course Title	:	Basic Electronics
Semester	:	03
Course Code	:	KU03DSCPHY202
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Basic Physics

Course Description:

- This course will introduce the band structure concept of conductors, insulators and semiconductors.
- Formation of pn junction will be discussed.
- Principles and operation of bipolar transistors will be explained.
- Characteristics of an ideal Op-amp will be discussed in this course.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	1	4	3	2	5	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Introduce the concepts of band structure of solids	R, U
2	Understand the basic concepts of pn junction formation	U, A
3	Understand the operation of a bipolar transistor and apply the idea in realizing the amplifier circuit	U, An, E
4	Understand the basics of operational amplifiers and digital electronics	U, A, E

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	2	2	1	1	1	-	-	-	-	-
CO2	3	2	2	1	1	1	-	-	-	-	-
CO3	3	2	2	1	1	1	-	-	-	-	-
CO4	3	2	2	1	1	1	-	-	-	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Content

Module I (9 Hours)
Introduction to conductors, semiconductors and insulators. band structure, Fermi level, mechanism of conduction in metals and semiconductors, mobility and conductivity, intrinsic and extrinsic semiconductors, doping, donor and acceptor levels, carrier lifetime.

Module II (12 Hours)
PN junction formation, Basic semiconductor devices: PN junction, band structure in open circuit PN junction, depletion region, PN diode: IV characteristics and its temperature dependence, space charge capacitance, diode resistance, half-wave and full-wave rectifiers, ripple factor, Filters: L, C, RC, LC and LCR filters.

Module III (12 Hours)
Bipolar transistors and operation: PNP and NPN transistors, transistor currents, active, saturation and cut-off regions, Common emitter amplifier, AC and DC analysis of transistor circuits, Amplifiers and differential amplifiers. Oscillators, Operating principles of FET, MOSFET.

Module IV (12 Hours)
Operational amplifiers: Ideal op-amp characteristics, common-mode rejection ratio, inverting and non-inverting configurations, Op-amp based circuits: summing, scaling and averaging amplifier, logarithmic amplifier. Digital Electronics: Boolean algebra, Binary number system, Conversion between different number systems, De Morgan's theorem, Karnaugh Map, Logic gates.

Module V* - Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Practicals (30 Hours): At least 6 Experiments to be performed

1. Characteristics of a semiconductor diode
2. Half wave & Full wave (2 diodes) Rectifiers - Study of ripple factor with and without filter (by soldering)
3. Bridge Rectifier- Study of ripple factor with and without filter (by soldering)
4. Voltage multiplier (Quadrupler) circuit (by soldering)
5. Voltage regulator using Zener diode after finding Zener voltage (Line and Load regulations)
6. Common Emitter characteristics of BJT
7. Single stage Common Emitter amplifier - Gain and Frequency response (by soldering)
8. Realization of basic logic gates (OR, AND & NOT) using transistors (by soldering)
9. Charging & discharging of a capacitor.
10. LCR resonance.

Core Compulsory Readings

1. S. M. Sze, Semiconductor Devices, Physics and Technology
2. A. Malvino and D. J. Bates, Electronic principles
3. Ramakant A Gayakwad, Op-amps and Linear Integrated Circuits
4. T L Floyd, Digital Fundamentals

Core Suggested Readings

1. J. Millman, C. C. Halkias and S. Jit. Electronic devices and circuits

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Explain the band structure of a solid.
2. Differentiate between extrinsic and intrinsic semiconductors.
3. Explain the process of formation of a pn junction.
4. Illustrate the operation of a transistor as an amplifier.

Quantum Physics: Basics

Course Title	:	Quantum Physics: Basics
Semester	:	03
Course Code	:	KU03DSCPHY203
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Mechanics, Optics

Course Description:

- This course will review the anomalies in classical physics and introduce the basic concepts of quantum mechanics.
- Wavelike properties of particles will be explained.
- The concept of Heisenberg's uncertainty relationships will be discussed and Schrodinger equation will be introduced.
- This course will illustrate Bohr model to explain the atomic structure.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	1	4	3	2	5	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Recall the concepts of classical physics and discuss the early anomalies in time and space description	R, U, An
2	Illustrate electron diffraction experiments and understand uncertainty relations	U, An
3	Learn the basics of quantum mechanics and understand the idea of probability density	U, An
4	Explain atomic spectra using quantum mechanics	U, A, An

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	2	2	1	1	1	-	-	-	-	-
CO2	3	2	2	1	1	1	-	-	-	-	-
CO3	3	2	2	1	1	1	-	-	-	-	-
CO4	3	2	2	1	1	1	-	-	-	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (12 Hours)
Review of classical physics; Early anomalies: The Deficiencies in the classical concepts of Time, Space, & Velocity, The perihelion precession of Mercury's orbit, The Michelson–Morley experiment, Failure of classical equipartition theorem - Heat capacities of an Ideal Gas; Blackbody Radiation - Appearance of Planck's constant h; Photoelectric effect; X-ray diffraction; Compton effect; Photon - waves or particles?

Module II (9 Hours)
The Wavelike properties of particles: de Broglie waves; Electron diffraction experiments; Uncertainty relationships for classical waves; Heisenberg uncertainty relationships; Wave packets; Group and Phase velocities; Probability and randomness; Probability amplitude.

Module III (12 Hours)
Particle in a Box - Behavior of a wave at the boundary, reflected and transmitted wave, continuity at the boundary; Quantum mechanics; The Schrodinger equation - Time dependent and steady state forms; Linearity and superposition; Probabilities and normalization; Expectation values; Operators; Applications: Free particle, Infinite & finite potential energy well; Particle in a box (two dimension), Simple harmonic oscillator; Potential energy steps and potential energy barriers- Tunnel effect, Alpha decay, & Nuclear fusion.

Module IV (12 Hours)
Basic properties of atoms; Thomson model; Rutherford scattering experiment; Rutherford model; Electron orbitals; Atomic spectra; Bohr model; Frank-Hertz experiment; Correspondence principle; Deficiencies of Bohr model; Nuclear motion - Fine structure; Atomic excitation.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Practicals (30 Hours): At least 6 Experiments to be performed

1. Thomson's experiment – To determine e/m ratio of an electron
2. Frank Hertz experiment – To determine the ionization potential.
3. Photoelectric effect – Determination of Planck's constant (White light and filters or LEDs of different colours may be used)
4. Spectrometer - Hydrogen spectra.
5. Newton's law of cooling- Specific heat of a liquid
6. Stefan's constant - Black body radiation.
7. Determination of band gap energy in silicon
8. Determination of band gap energy in germanium.
9. Program to plot the Fermi distribution as a function of temperature.
10. Simulation experiments using ExpEYES-SEELAB/ Virtual lab/PhET simulations

Core Compulsory Readings

1. Kenneth S Krane, Modern Physics (4/e), John Wiley & sons (2020)
2. Arthur Beiser, Concepts of Modern Physics (6/e), McGraw Hill (2003)

Core Suggested Readings

1. The Feynman lectures on Physics (Vol - III).

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

<table>
<tr><th colspan="3">Assessment Rubrics</th><th>Total</th></tr>
<tr><td>End Semester Evaluation</td><td>External Test</td><td>50</td><td>50</td></tr>
<tr><td rowspan="4">Continuous Evaluation</td><td>Internal Exams</td><td>20</td><td rowspan="4">50</td></tr>
<tr><td>Assignments</td><td>10</td></tr>
<tr><td>Seminar</td><td>10</td></tr>
<tr><td>Viva</td><td>10</td></tr>
</table>

Sample Questions to test Outcomes

1. Discuss the failure of classical equipartition theorem.
2. Describe black body radiation.
3. Discuss Heisenberg's uncertainty relations.
4. Explain particle in a box problem.

Introduction to Solid State Physics

Course Title	:	Introduction to Solid State Physics
Semester	:	03
Course Code	:	KU03DSCPHY204
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Electricity & Magnetism, Mechanics

Course Description:

- This course will introduce the basics of crystal structure.
- Concepts of chemical bonding will be explained with the help of examples.
- Free electron theory and Hall effect will be discussed in detail.
- The concepts of electrons and holes in semiconductors will be discussed in the context of band structure.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	1	4	3	2	5	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Illustrate crystalline and amorphous solids with examples and discuss the reciprocal lattice space	R, U, An
2	Explain the concepts of phonons in crystal lattice and illustrate chemical bonding	U, An
3	Understand free electron theory and evaluate the thermal and electrical conductivity of metals.	U, An, E
4	Explain the basics of band theory in solids and evaluate the carrier dynamics in semiconducting materials	U, A, E

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	3	1	1	1	1	-	-	-	-	-
CO2	3	3	1	1	1	1	-	-	-	-	-
CO3	3	3	1	1	1	1	-	-	-	-	-
CO4	3	3	1	1	1	1	-	-	-	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (9 hours)
Crystalline and amorphous solids; Fundamental lattice types; Simple crystal structures; SC, BCC, FCC and HCP structures; Directions, planes and Miller indices; Diffraction, Bragg's Law, Reciprocal Lattice.

Module II (12 Hours)
Chemical Bonding (Ionic, covalent, hydrogen, metallic). Lattice Dynamics, Phonons. Brillouin zones. Group and phase velocity. Thermal Properties. Normal modes, Density of states, Einstein model, Debye theory.

Module III (12 Hours)
Electrons in metals; Free electron theory; Free electron gas in 1D, 2D, 3D; Heat capacity. Electrical conductivity; Ohms law; Hall effect; Thermal conductivity; Applications of Hall effect; Nearly free electron approximation; Bloch theorem and band structure.

Module IV (12 Hours)
Semiconductors; Intrinsic and extrinsic semiconductors; Electrons, Holes, Impurities; Band structure of semiconductors; Fermi level of intrinsic and extrinsic semiconductors; Fermi level and carrier concentration in semiconductors; Mobility of charge carriers; Electrical conductivity in semiconductors; Magnetic properties of materials. Concepts of Dia-, Para-, Ferro- and Antiferro- Magnetism.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Practicals (30 Hours): At least 6 Experiments to be performed

1. Hall Effect in semiconductors – To determine the carrier concentration in the given specimen of semiconductor material.
2. Lee's disc- Thermal conductivity of a bad conductor
3. Thermal conductivity - Charton's Method
4. Four probe method – To study the bulk resistance and the band gap energy of the given semiconductor.
5. Beer-Lambart's Law
6. Characteristics of a semiconductor diode
7. Thin film deposition and characterization.
8. Magnetic hysteresis using B-H curve.
9. Magnetic susceptibility of dia- and para- magnetic materials.
10. Simulation experiments using ExpEYES-SEELAB/ Virtual lab/PhET simulations

Core Compulsory Readings

1. C. Kittel, Introduction to Solid State Physics (8/e), John Wiley & Sons, Inc. (2004).
2. H. Ibach & H. Luth, Solid State Physics (3/e), Springer (2003).

Core Suggested Readings

1. N. W. Ashcroft and D. N. Mermin, Solid State Physics, Harcourt Asia PTE LTD (2001).

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Discuss Miller indices in crystal structure.
2. Discuss lattice vibrations and derive the density of states in momentum space.
3. Explain free electron theory.
4. Explain Hall effect and discuss the main applications of Hall effect.

Semester - IV

Electromagnetic Theory I

Course Title	:	Electromagnetic Theory-I
Semester	:	04
Course Code	:	KU04DSCPHY201
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Electricity & Magnetism

Course Description:

- This course will review and analyze the dielectric properties of matter and the field of a polarized object.
- Basic concepts of magnetization and Ampere's law will be introduced.
- Faraday's law of electromagnetic induction will be discussed.
- The concepts of energy and momentum of electromagnetic waves will be discussed.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	1	4	3	2	5	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Understand and analyze the field of a polarized object and learn the concept of electric susceptibility	R, U, An
2	Illustrate magnetization in matter and learn the concept of magnetic susceptibility	U, An
3	Recall Ohm's law and understand electromagnetic induction	R, U, An
4	Explain Maxwell's equations in vacuum and matter and learn the physical implications of electromagnetic boundary conditions	U, A, An

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	1	1	1	1	-	-	-	-	-
CO2	3	3	1	1	1	1	-	-	-	-	-
CO3	3	3	1	1	1	1	-	-	-	-	-
CO4	3	3	1	1	1	1	-	-	-	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (9 Hours)
Polarisation: Dielectrics - Field of a polarised objects- Bound charges - Field inside a Dielectric, Electric Displacement, Gauss's Law in presence of Dielectrics, Linear Dielectrics - electric susceptibility - Permittivity - Dielectric constant - Energy and Forces in Dielectrics.

Module II (12 Hours)
Magnetic vector potential - Diamagnet - Paramagnets - Ferromagnets - Torque and Forces on magnetic Dipoles, Effect of magnetic field on Atomic Orbits - Magnetization, Field of a magnetised objects - Magnetic field inside matter - Ampere's law in magnetised Materials and applications - Magnetic Susceptibility, Permeability- Ferromagnetism.

Module III (12 Hours)
Electromotive Force-Ohm's Law, Faraday's Law of Electromagnetic Induction - Induced electric Field - Inductance - Energy in Magnetic Fields, Maxwell's Equations in vacuum and matter - Boundary conditions, Continuity equation, Poynting Theorem, Conservation Laws-Maxwell's Stress Tensor.

Module IV (12 Hours)
Waves in one dimension: Wave equation - Boundary Conditions - Polarisation, Electromagnetic waves in Vacuum - Wave equation for **E** and **B** - Monochromatic Plane Wave - Energy and Momentum in EM waves.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Practicals (30 Hours): At least 6 Experiments to be performed

1. Searle's Vibration magnetometer- moment and ratio of moments
2. Verification of Thevenin's and Norton's theorem
3. Quincke's method – Susceptibility of a liquid at different concentrations.
4. Laser – Determination of refractive index of a mirror substrate.
5. Maxwell's LC bridge – Determination of R and L of a given coil and C of a condenser.
6. Carey Foster's bridge - unknown resistance.
7. Deflection magnetometer - determine the pole strength of a magnet.
8. Magnetic field along the axis of Helmholtz coil.
9. Simulation experiments using ExpEYES-SEELAB/ Virtual lab/PhET simulations

Core Compulsory Readings

1. D. J. Griffiths, Introduction to electromagnetic theory (3/e)
2. Edward M. Purcell, Electricity and Magnetism - Berkeley Physics Course: Vol.2 (2/e)
3. Resnick and Halliday, Physics Vol. II

4. Arthur F Kip, Electricity and Magnetism

Core Suggested Readings

1. Hugh D Young and Roger A Freedman, Electricity and Magnetism

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Explain the basics of electrical susceptibility.
2. Discuss magnetization in materials.
3. Explain Poynting theorem.
4. Explain energy and momentum conservation of electromagnetic waves in vacuum.

Thermodynamics

Course Title	:	Thermodynamics
Semester	:	04
Course Code	:	KU04DSCPHY202
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Electricity & Magnetism, Mechanics

Course Description:

- This course will introduce the concept of temperature and discuss the properties of ideal gas.
- Concepts of work and heat will be illustrated with the help of examples.
- The second law of thermodynamics and principle of heat engine will be discussed.
- The concepts entropy and thermodynamic potential will be introduced.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Illustrate microscopic and macroscopic point of view in thermodynamics	R, U, An
2	Explain the concepts of work and heat and discuss heat conduction	U, An
3	Understand the second law of thermodynamics and illustrate reversible and irreversible processes	U, An, E
4	Explain the concept of entropy and discuss Maxwell's relations	U, A, E

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	3	2	1	1	1	-	-	-	-	-
CO2	3	3	2	1	1	1	-	-	-	-	-
CO3	3	3	2	1	1	1	-	-	-	-	-
CO4	3	3	-	-	-	-	-	-	-	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (15 Hours)
Macroscopic point of view - Microscopic point of view - Macroscopic and microscopic point of view - Macroscopic vs. microscopic point of view - scope of Thermodynamics - thermal equilibrium - zeroth law - concept of temperature - thermometers and measurement of temperature - ideal gas temperature - Celsius temperature scale - Celsius and Fahrenheit temperature scale - thermodynamic equilibrium - equation of state - intensive and extensive parameters.

Module II (15 Hours)
Work-Quasistatic process - work in changing volume of a hydrostatic system - PV diagram - hydrostatic work depends on path - calculation of work for Quasistatic process - generalised work - composite systems - work and heat - Adiabatic work - internal energy Function - mathematical formulation of first law - concept of heat - concept of path and state function - differential form of first law - heat capacity and measurements - specific heat of water, the calorie - equations for a hydrostatic system - heat reservoir - heat conduction - heat convection - radiation - Kirchoff and Stefan - Boltzmann law, Equation of state of a gas - internal energy of a real gas - ideal gas - quasistatic adiabatic process - kinetic theory of the ideal gas.

Module III (15 Hours) : The second law of thermodynamics, Carnot cycle, and Thermodynamic temperature scale
Conversion of work into heat and vice - versa - principle of heat engines, cyclic process - gasoline engine and its efficiency, Diesel engine and its efficiency - heat engine kelvin Planck statement of second law - refrigerator, clausius statement of second law - equivalence of both - reversibility and irreversibility - external - internal mechanical Irreversibility - external - internal thermal irreversibility - chemical irreversibility - conditions for reversibility - Carnot cycle - Carnot Refrigerator - Carnot's theorem and Corollary - the thermodynamic temperature scale - Absolute zero and Carnot efficiency - equality of ideal gas and thermodynamic temperatures.

Module IV (15 Hours): Entropy, Thermodynamic potentials, and Statistical distributions
Entropy, thermodynamic potentials and open systems Reversible part of second law - Entropy - entropy of an ideal gas - T - S diagram - entropy and reversibility - entropy and Irreversibility - irreversible part of second law - heat and entropy in irreversible processes - entropy and non equilibrium states - principle of increase of entropy - entropy and disorder Thermodynamic potentials - Internal energy, Enthalpy - Helmholtz free energy, Gibbs function - Maxwell's relations, joule Thomson expansion - first order phase Transition, clausius clapeyron equation - clausius clapeyron equation and phase diagrams. Ideas of ensembles, Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein distributions.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Core Compulsory Readings

1. Mark W Zemansky and Richard H Dittman, Heat and Thermodynamics (8/e)
2. Kenneth S Krane, Modern Physics (4/e) (An Indian Adaptation) -

3. E V Guha, Basic thermodynamics
4. SC Garg, RM Bansal, CK Ghosh, Thermal Physics, (2/e) McGraw-Hill
5. F. Reif, Fundamentals of Statistical and Thermal Physics, Waveland Press Inc.

Core Suggested Readings

1. F. Reif, Statistical Physics, Berkeley Physics Course, Volume 5, Tata McGraw-Hill

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

<table>
<tr><th colspan="3">Assessment Rubrics</th><th>Total</th></tr>
<tr><td>End Semester Evaluation</td><td>External Test</td><td>50</td><td>50</td></tr>
<tr><td rowspan="4">Continuous Evaluation</td><td>Internal Exams</td><td>20</td><td rowspan="4">50</td></tr>
<tr><td>Assignments</td><td>10</td></tr>
<tr><td>Seminar</td><td>10</td></tr>
<tr><td>Viva</td><td>10</td></tr>
</table>

Sample Questions to test Outcomes

1. Explain the zeroth law of thermodynamics.
2. Discuss intensive and extensive parameters.
3. Explain adiabatic work and discuss mathematical formulation of first law of thermodynamics.
4. Discuss the principle of heat engines.

Introduction to Astrophysics

Course Title	:	Introduction to Astrophysics
Semester	:	04
Course Code	:	KU04DSCPHY203
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Mechanics, Quantum Physics

Course Description:

- This course will discuss the basic tools required in Astronomy.
- Interstellar activities will be discussed in detail.
- The course includes study of stellar evolution.
- Various galaxy types and structures will be an active part of the course.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Learn basic tools of astronomy and understand stellar classification.	U, A
2	Understand interstellar activities.	U, A
3	Learn stellar evolution.	U, An
4	Classify galaxy types and stellar population according to their properties.	U, An

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	3	-	2	1	-	-	-	2	-	-
CO2	3	3	-	2	1	-	-	-	2	-	-
CO3	3	3	-	2	1	-	-	-	2	-	-
CO4	3	3	-	2	1	-	-	-	2	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (18 Hours): Basic Tools of Astronomy
Stellar distance-relationship between stellar parallax and distance, brightness and Luminosity - relation between luminosity, brightness, and distance, Magnitudes - Apparent magnitude and brightness ratio - relationship between apparent magnitude and absolute Magnitude - Colour and temperature of the star - relationship between flux, luminosity, and Radius - stellar spectra - stellar classification - Hertz prong Russell diagram - H - R diagram and stellar radius - H -R diagram and stellar luminosity - H -R diagram and stellar mass.

Module II (12 Hours): Interstellar Medium
Nebulae, Emission Nebulae, Dark Nebulae, Reflection Nebulae, Molecular Clouds, Protostars, The Jeans Criterion.

Module III (15 Hours): Stars
Star clusters, Red Giants and the H - R Diagram - The Death of Stars - The Asymptotic Giant Branch - Dredge - Ups - Mass Loss and Stellar Winds - Infrared Stars - The End of an AGB Star's Life - White Dwarf Stars - High-Mass Stars and Nuclear Burning - The End Result of High - Mass Stars' Evolution: Pulsars, Neutron Stars, and Black Holes.

Module IV (15 Hours): Galaxies
Galaxy Types, Galaxy Structure, Stellar Populations, Hubble Classification of Galaxies, Observing Galaxies - Spiral Galaxies - Barred Spiral Galaxies- Elliptical Galaxies - Lenticular Galaxies, Active Galaxies and AGNs, Gravitational Lensing, Redshift, Distance, and the Hubble Law.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Core Compulsory Readings

1. Mike Ingis, Astrophysics is Easy: An introduction for the Amateur Astronomer, Springer.
2. H. Karttunen, P. Kröger, H. Oja, M. Poutanen, K. J. Donner, Fundamental Astronomy (5/e), Springer
3. Baidyanath Basusu M, An introduction to Astrophysics, Prentice Hall of India

Core Suggested Readings

1. B.W. Carroll & D.A. Ostille, Modern Astrophysics, Addison Wesley (1996)

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

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- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Describe stellar parallax and distance relationship.
2. Describe the H-R diagram.
3. Describe stellar evolution.
4. Discuss galaxy classifications.

Introduction to Nuclear & Particle Physics

Course Title	:	Introduction to Nuclear & Particle Physics
Semester	:	04
Course Code	:	KU04DSCPHY204
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Quantum Physics

Course Description:

- This course will help to identify nuclear constituents and general properties of nuclei and distinguish different nuclear models.
- Describe the phenomenon of radio activity.
- Discuss nuclear reactions including fission and fusion processes.
- Basic classification of elementary particles will be discussed.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	1	4	3	2	5	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Identify nuclear constituents and general properties of nuclei and distinguish different nuclear models.	U, An
2	Describe the phenomenon of radio activity.	U, An
3	Describe the nuclear fission and fusion processes.	U, An
4	Classify the elementary particles and relate their properties.	U, An

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	-	2	1	-	-	-	2	-	-
CO2	3	3	-	2	1	-	-	-	2	-	-
CO3	3	3	-	2	1	-	-	-	2	-	-
CO4	3	3	-	2	1	-	-	-	2	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (9 Hours): Nuclear Structure
Nuclear Composition; Nuclear properties- nuclear mass, nuclear size, magnetic moment, angular momentum; binding energy; liquid drop model; shell model; Nuclear force; Meson theory

Module II (12 Hours): Nuclear Radioactivity
Radioactive decay; Half life; Conservation laws in radioactive decay; radioactive series; Alpha decay- tunnel theory of alpha decay; Beta decay; Gamma decay; resonance; Natural radioactivity; Mossbauer effect.

Module III (12 Hours): Nuclear Reactions and Applications
Types of nuclear reactions; Reaction cross-section, Radioisotope production in nuclear reactions; Low-energy reaction kinematics; Fission; Fission reactors; Fusion; Fusion processes in stars, Fusion reactors; Applications of nuclear physics.

Module IV (12 Hours): Elementary Particles
The four basic forces; Particles and antiparticles; Families of particles; symmetries and Conservation laws; Particle interactions and decays; Energy and momentum in particle decays and reactions; The Quark Model; The Standard Model and beyond.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Practicals (30 Hours): At least 6 Experiments to be performed

1. G.M counter – Plateau and statistics of counting.
2. G.M counter - operating voltage and to verify the distribution law satisfied by the radioactive decay.
3. Absorption coefficient of "gamma" rays – To determine the absorption coefficient of a given material for CS 137 gamma rays using GM counter.
4. Absorption coefficient of "beta" rays – To determine the Absorption coefficient of a given material for beta ray source using GM counter.
5. ESR spectrometer - Lande's g factor
6. Program to calculate the half life of a radio active element.
7. Program to calculate the tunneling decay coefficient in alpha decay.
8. Simulation experiments using ExpEYES-SEELAB/ Virtual lab/PhET simulations

Core Compulsory Readings

1. Arthur Beiser, Concepts of modern physics (7/e), TATA McGRAW-HILL.
2. Kenneth S. Krane, Modern Physics (4/e), John Wiley & sons.

Core Suggested Readings

1. Nuclear Physics, D C Tayal, Himalaya Publishing House

Teaching Learning Strategies

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- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Describe the liquid drop model of nuclear structure.
2. Discuss the conservation laws in radio active decay
3. Describe the fusion process in stars.
4. Discuss the four basic forces and describe the classification of elementary particles.

Semester - V

Mathematical Physics I

Course Title	:	Mathematical Physics I
Semester	:	05
Course Code	:	KU05DSCPHY301
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Algebra, Differential and Integral Calculus

Course Description:

- This course aims to equip the students with the mathematical techniques used for developing strong background in the basic and advanced level problems.
- The course provides basic and advanced concepts in curvilinear coordinates, complex functions, and applications of complex theory.
- This paper also gives insights to special functions, tensors and group theory.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Solve physical problems using vector algebra.	R, U, An
2	Apply mathematical principles and concepts of matrices to solve practical problems.	U, An
3	Develop skill to solve problems based on complex variables.	U, An
4	Analyze and solve linear differential equations.	U, A, An

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	3	-	-	1	-	-	-	2	-	-
CO2	3	3	-	-	1	-	-	-	2	-	-
CO3	3	3	-	-	1	-	-	-	2	-	-
CO4	3	3	-	-	1	-	-	-	2	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (15 hours): Determinants, Matrices, Eigenvalue problems
Determinants - Homogeneous and Inhomogeneous Linear Equations - Cramer's rule - properties and applications of determinants, Matrices: Basic Properties - inner product- Orthogonal - Hermitian and Unitary Matrices, Diagonalization of Matrices -Simultaneous Diagonalization.

Module II (15 hours): Tensors
Direct product, Tensor Analysis:Definition of Tensors - Covariant and Contravariant Tensors- Symmetry- Contraction - Direct Product - Quotient rule - Pseudo Tensors - Dual tensors - Metric Tensors - Kronecker Delta and Levi - Civita Tensors, Jacobians.

Module III (15 hours): Vector Analysis
Vector algebra: vector operations-component form- Triple product- Position, Displacement, and Separation Vectors, Differential calculus:-Derivatives-Gradient-Divergence-Curl-Product rule-Second derivatives, Integral calculus:-Line,Surface,Volume integrals-Fundamental Theorem for Gradients-Divergence-Curls, Curvilinear Coordinates:-Polar, Cylindrical, and Spherical polar coordinates , Dirac delta function.

Module IV (15 hours): Special Function
Special Functions: Gamma Function, Beta Function, Bessel Functions of First and Second Kinds: Generating Function, Recurrence Relations, Orthogonality, Neumann Function - Legendre Polynomials: Generating Function, Recurrence Relations, Rodrigue's Formula, Orthogonality - Associated Legendre Polynomials - Spherical Harmonics - Hermite Polynomials - Laguerre Polynomials.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Core Compulsory Readings

1. G.B.Arfken and H.J.Weber, Mathematical Methods for Physicists (6/e), Academic Press (2005)
2. A. W. Joshi, Matrices & Tensors in Physics (3/e), New Age International (2005).
3. K. F. Riley and Hobson, Mathematical Methods for Physicists and Engineers, Cambridge.
4. Michel Tabor, Chaos and Integrability in Nonlinear Dynamics, Wiley Eastern.
5. Sathyaprakash, Mathematical Physics, S. Chand & CO

Core Suggested Readings

1. Pipes and Harvill, Applied Mathematics for Physicists and Engineers, McGraw Hill.
2. R. Courant and D. Gilbert, Methods of Mathematical Physics, Wiley Eastern.

Teaching Learning Strategies

- Developing conceptual understanding

- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Find a unit vector normal to the surface $x^2 + y^2 - 2z = 1$ at the point $P(1, 1, 1)$
2. Show that the contraction of a tensor reduces its rank by two.
3. Evaluate the residue at its pole of the function $\frac{ze^2}{(z-a)^2}$
4. Prove that $H_n(x) = (-1)^n H_n(-x)$

Electromagnetic Theory II

Course Title	:	Electromagnetic Theory-II
Semester	:	05
Course Code	:	KU05DSCPHY302
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Electricity & Magnetism

Course Description:

- This course will establish advanced concepts of electromagnetic theory and waveguiding.
- The basics of dipole radiation and antenna design will be discussed.
- The basic concepts in relativistic electrodynamics will also be covered.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	1	4	3	2	5	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Explain and discuss the propagation of electromagnetic waves through different media.	R, U, E
2	Explain waveguiding and supported modes.	U, An
3	Use radiation theory in developing different antennas structures.	U, An
4	Describe the basic formulations of relativistic electrodynamics.	U, A, An

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	3	2	2	1	1	-	-	2	1	-
CO2	3	3	2	2	1	1	-	-	2	1	-
CO3	3	3	2	2	1	1	-	-	2	1	-
CO4	3	3	2	2	1	1	-	-	2	1	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (12 Hours)
Electromagnetic waves in linear media; The flow of electromagnetic Energy; Poynting Vector; Boundary conditions; Plane monochromatic waves; Polarization of plane waves- Linear, Circular, Elliptic etc.; Reflection and refraction of electromagnetic waves at a plane surface between dielectric media: normal incidence and oblique incidence; Brewster's angle, Critical angle ,complex Fresnel coefficients; Reflection from a conducting plane.

Module II (12 Hours)
Potentials and fields, Gauge Transformations: Lorerntz and Coulomb Gauge, Retarded Potentials: Jefimenko's equations, The field of a moving point charge, Electric and Magnetic dipole radiations, Radiation from an arbitrary source, Power radiated by a point charge.

Module III (9 Hours)
Radiation from Hertzian dipole; Half wave dipole antenna, Quarter wave monopole antenna; Antenna characteristics; Antenna arrays; Effective area and Fris equations.

Module IV (12 Hours)
The special theory of relativity: Einstein's postulates, Geometry of relativity, Lorentz Transformations, Structure of space-time, Relativistic Mechanics: Proper time and proper velocity, Relativistic energy and momentum, Relativistic kinematics and dynamics, Relativistic electrodynamics: magnetism as a relativistic phenomena, Field transformations.

Module V *: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Practicals (30 Hours): At least 6 Experiments to be performed

1. Plotting of the 2D functions in Python.
2. Mapping of 2D vector fields in Python.
3. Prepare codes to map electric and magnetic field lines.
4. Write a program to simulate the particle trajectory under Lorentz force law.
5. Write a program to plot reflection coefficients for TE modes.
6. Write a program to plot reflection coefficients for TM modes.
7. Write a program to calculate and plot the transmittance of a thin film of finite thickness.
8. Write a program to calculate and plot the transmittance as a function of thickness for a given material.
9. Write a program to calculate and plot the transmittance/reflection/absorption as a function of incident angle.

Core Compulsory Readings

1. Capri A. Z. and Pant P.V., Introduction to Electromagnetics, Narosa Publications.

2. John R. Reitz, Frederic J. Milford and Robert W. Christy, Foundations of Electromagnetic Theory, Narosa Publications.
3. David. J. Griffiths, Introductions to Electrodynamics (4/e), Prentice Hall.
4. Chen. F. F., Introduction to Plasma Physics and Controlled Fusion, Plenum.
5. Jackson J.D, Classical Electrodynamics (3/e), John Wiley.
6. David Cheng, Field and Wave Electromagnetics (3/e), Pearson Education Asia.
7. Sadik, Electromagnetics.

Core Suggested Readings

1. Puri S. P, Classical Electromagnetics (2/e), Tata McGraw Hill.
2. Laud B. B, Electromagnetics (3/e), Wiley Eastern.
3. Chopra K. K. and Agarwal G. C., Electromagnetic Theory (4/e), K. Nath and Co., Meerut.

Teaching Learning Strategies

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- Emphasizing problem solving skills
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Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Explain Maxwell's equations.

2. Illustrate the formulations and relativistic effects in electrodynamics.
3. Describe the propagation of electromagnetic waves through waveguides.
4. Explain the concepts of reflection, refraction, and absorption of electromagnetic waves.
5. Describe the behavior of electromagnetic waves in different media, such as air, water, and glass.
6. Describe the behavior of electric fields and magnetic fields in free space.

Quantum Physics: Applications

Course Title	:	Quantum Physics: Applications
Semester	:	05
Course Code	:	KU05DSCPHY303
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Quantum Physics: Basics

Course Description:

- This course will discuss the quantum theory of hydrogen atom.
- Many electron systems will be discussed.
- The basics of statistical mechanics will be introduced along with the Planck's radiation law.
- Fundamentals of spectroscopic techniques will also be covered during this course.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Solve quantum theory of hydrogen atom	R, U, E
2	Understand the discrete energy level transitions and illustrate the fine structure of H atom	U, An
3	Learn the fundamentals of statistical mechanics and understand the three basic statistical distributions	U, An
4	Explain atomic spectra using quantum mechanics	U, A, An

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	3	-	-	2	-	-	-	-	-	-
CO2	3	3	-	-	2	-	-	-	-	-	-
CO3	3	3	-	-	2	-	-	-	-	-	-
CO4	3	3	-	-	2	-	-	-	-	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (15 Hours)
Quantum theory of hydrogen atom; Angular momentum of classical orbits; Angular momentum in quantum mechanics; Schrodinger equation for H-atom in spherical polar coordinates; Separation of variables; Hydrogen atom wave functions; Radial probability densities; Angular momentum and probability densities; Quantum numbers; Intrinsic spin; Stern – Gerlach experiment; Energy levels and radiative transitions; Zeeman effect; Fine structure.

Module II (15 Hours)
Many electron atoms: Electron spin & Pauli's Exclusion principle; Symmetric and antisymmetric wave functions; Spin-orbit coupling; Total angular momentum; X-Ray transitions.

Module III (15 Hours)
Statistical mechanics-basics; Three basic statistical distributions; Density of states; Maxwell - Boltzmann statistics; Molecular energies in an ideal gas; Quantum statistics; Rayleigh-Jeans formula; Plank's radiation law; Einstein's approach - stimulated emission; Specific heats of solids; Free electrons in metals; Dying stars.

Module IV (15 Hours)
Spectroscopy: Regions of the spectrum; Microwave spectroscopy; The rotation of molecules; Rotational spectra; The rigid diatomic molecule; Intensities of spectral lines; The effect of isotopic substitution; The microwave oven; The vibrating diatomic molecule; The energy of diatomic molecule; The Simple Harmonic Oscillator. Introduction to Raman spectroscopy.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Core Compulsory Readings

1. Kenneth S Krane, Modern Physics (4/e), John Wiley & sons (2020)
2. Arthur Beiser, Concepts of Modern Physics (6/e), McGraw Hill (2003)
3. Colin N. Banwell and Elaine M McCash, Fundamentals of Molecular Spectroscopy (5/e), Tata McGraw-Hill (2013)

Core Suggested Readings

1. The Feynman lectures on Physics (Vol - III).

Teaching Learning Strategies

- Developing conceptual understanding
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- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Solve Schrodinger equation for H-atom in spherical polar coordinates.
2. Explain Zeeman effect.
3. Discuss fine structure of H-atom.
4. Discuss stimulated emission.

KANNUR UNIVERSITY

Numerical Methods in Physics

Course Title	:	Numerical Methods in Physics
Semester	:	05
Course Code	:	KU05DSCPHY304
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Mathematics for Physical Science

Course Description:

- This course will provide a solid foundation in different numerical methods for solving complex problems.
- Students will be equipped to apply the techniques in their higher studies.
- This course serves as the foundation for advanced computational Physics and statistical data Analysis.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	1	4	3	2	5	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Understand and apply different methods to find the roots of nonlinear equations to solve problems.	U, A
2	Understand and apply different interpolation methods and curve fitting methods.	U, A
3	Understand different methods of numerical differentiation and integration and apply those methods to solve problems	U, A, E
4	Understand the methods to solve ordinary and partial differential equations.	U, A, E

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	3	-	-	1	-	-	-	-	-	-
CO2	3	3	-	-	1	-	-	-	-	-	-
CO3	3	3	-	-	1	-	-	-	-	-	-
CO4	3	3	-	-	1	-	-	-	-	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Module I (12 Hours) Roots of Equations
Bi-Section Method, False Position Method, Newton-Raphson Method, Secant Method, Two Equation Newton-Raphson Method, Mullers Method, Gauss elimination method, Gauss elimination with pivoting, Gauss-Jordan method, Computing Matrix Inverse, Jacobi Iteration Method, Gauss-Seidel Method.

Module II (12 Hours) Curve Fitting
Linear Interpolation, Lagrange Interpolation, Newton Interpolation, Interpolation with Equidistant Points, Forward, Backward difference Table, Fitting Linear Equation: Least Square Method , Fitting Polynomial Function.

Module III (12 Hours) Numerical differentiation and Integration
Differentiating continuous functions: Forward difference only, Differentiating tabulated functions, Trapezoidal Rule, Simpson's 1/3 rule, Simpson's 3/8 rule, Boole's Rule.

Module IV (9 Hours) Ordinary & Partial Differential Equations
Taylor Series Method, Eulers Method, Rung Kutta Methods, Elliptic Equation: Laplace Equation, Parabolic Equation : Heat Equation.

Module V* - Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Practicals (30 Hours): At least 6 Experiments to be performed

1. Root of a nonlinear equation using the bisection method
2. Root of an equation by false position method
3. Root of an equation by Newton-Raphson method
4. Root of a nonlinear equation by secant method
5. Root of a polynomial using Muller's method
6. Solution of first order differential equation using Runge-Kutta method
7. Integrate a given function using trapezoidal rule
8. Integrate a given function using the Simpsons 1/3 rule
9. Integrate a given function using the Simpsons 3/8 rule
10. Least square fitting.
11. Numerical interpolation using Newton and Lagrangian methods
12. Program to solve a system of linear equations using simple Gaussian elimination method
13. Solution of the first order differential equation at a given point using Euler's method
14. First derivative of tabulated function by difference table

Core Compulsory Readings

1. E Balaguruswamy, Numerical Methods, McGraw Hill Education

Core Suggested Readings

1. S. S. Sastry, Introductory method of Numerical analysis, Fifth Edition, PHI (2012).
2. V. N. Vedamurthy and N. Ch. S. N. Iyengar, Numerical methods, Vikas Publishing House, Pvt Ltd. New Delhi, India.
3. P. Ghosh, Numerical Methods with computer programs in C++,PHI learning Pvt Ltd.
4. F.B.-Hildebrand, Introduction to Numerical Analysis, Second Edition.
5. Richard Hamming, Numerical Methods for Scientists and Engineers.

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Find the root of a nonlinear equation using the bisection method
2. Integrate a given function using trapezoidal rule
3. Write a program to solve a system of linear equations using simple Gaussian elimination method

Biophysics

Course Title	:	Biophysics
Semester	:	05
Course Code	:	KU05DSEPHY301
Course Type	:	DSE
Course Credits	:	4
Pre-requisites	:	Basic concepts of Physics & Biology

Course Description:

- This course will introduce fundamentals of biophysics
- Students will have a solid understanding of protein structure determination.
- The course introduce neurotransmitters and synapses.
- Light absorption in biomolecules and mechanical properties of biomaterials will be discussed.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Learn the basics of biophysics and understand the essential physical process in a living organism.	U
2	Understand thermodynamics of living state.	U
3	Understand neurotransmittance and mechanical properties of biomaterials.	U, An
4	Learn basic structure determination of proteins using x-ray crystallography.	U, E

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	1	1	1	-	-	1	2	-	-
CO2	3	3	1	1	1	-	-	1	2	-	-
CO3	3	3	1	1	1	-	-	1	2	-	-
CO4	3	3	1	1	1	-	-	1	2	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (15 Hours)
Fundamental building blocks of biological systems, Molecules essential for life, Water, proteins, lipids, carbohydrates, cholesterol, Nucleic acid, living state interactions, forces and molecular bonds, electric and thermal interaction, polarisations and induced dipoles, Casimir interactions, heat transfer in biomaterials, heat transfer mechanisms, heat equation, heat transfer through a living cell, Joule heating tissue.

Module II (15 Hours)
Living state thermodynamics, thermodynamic equilibrium, First and second law of thermodynamics, measures of entropy, free expansion of gas, physics of many particle systems, Boltzmann factor in biology, DNA stretching, Brownian motion, Ficks laws of diffusion, Ficks law for growing bacterial cultures, Sedimentation of cell cultures.

Module III (15 Hours)
Nerve impulses, Neurotransmitters and synapses, Passive and active transports in dendrites, Mechanical properties of biomaterials, Youngs, shear modulus and Poisson ratio, electrical stresses in biological membranes, Mechanical effects of microgravity during space flight, fundamentals of biomagnetic field sources- fundamentals, Passive electrical properties of living cells.

Module IV (15 Hours)
Light absorption in biomolecules, Bioimpedance, Time harmonic current flow, Dielectric spectroscopy, Debye relaxation model, Cole equation, Fundamentals of protein folding, basic techniques for protein folding, protein crystallization, Vapor diffusion, sitting drop method, Hanging drop method, Basics of structure determination of proteins with X-ray crystallography, sample handling techniques.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Core Compulsory Readings

1. J. Claycomb, J. Quoc P. Tran, Introductory biophysics: Perspectives on the living state, Jones & Bartlett Publishers.
2. N. Arumugam, V. Kumaresan, Biophysics; Saras publication.
3. Philip Nelson, Biological Physics; W. H. Freeman & Company (2013).
4. Charis Ghelis, Protein Folding; Academic Press (1982).
5. McPherson, A., Preparation and Analysis of Protein Crystals (1982), John Wiley & Sons.

Core Suggested Readings

1. Terese M. Bergfors, Protein Crystallization Techniques, Strategies and Tips, International University Line (1999)

Teaching Learning Strategies

- Developing conceptual understanding

- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Discuss the electrical and thermal interactions in a living organism.
2. Discuss heat transfer processes in biomaterials.
3. Describe Ficks law of diffusion.
4. Describe the mechanical effects of microgravity during space flight.

Python Programming

Course Title	:	Python Programming
Semester	:	05
Course Code	:	KU05DSEPHY302
Course Type	:	DSE
Course Credits	:	4
Pre-requisites	:	Basic Computational Skills

Course Description:

- This course will equip the students with computational skills to visualize the physical concepts.
- The course will introduce necessary numerical techniques and the Python interface will be used to execute the algorithm.
- The data analysis part of the practicum components of the core courses will benefit from this course.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	1	4	3	2	5	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Develop skills in creating program sketches of scientific problems	R, U, An
2	Develop basic skills in logical thinking and programming	U, An
3	To make real-life scientific problems easier on a computer with user interaction and graphics	U, An, E
4	Visualize scientific concepts with advanced level data plotting	U, A, E

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	3	1	1	1	-	-	1	2	-	-
CO2	3	3	1	1	1	-	-	1	2	-	-
CO3	3	3	1	1	1	-	-	1	2	-	-
CO4	3	3	1	1	1	-	-	1	2	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (13 Hours): Introduction to Python Programming
Introduction to Python language- Python interpreter -interactive and script modes-Variables and data types-Numbers, None, Sequences-string (create, access and manipulate string)-list (create, access and manipulate list objects)-tuple-Mutable and immutable variables-Operators and Operands-arithmetic, relational, logical and assignment operators-Expressions and Statements-Precedence of operators-Input and Output-Comments in python- File input/output-Programming exercises with applications in Physics.

Module II (8 Hours): Functions in Python
Functions- Parameters and Arguments-Modules (NumPy and Mathplotlib modules)-Use of Modules in Program (Import and From)-Python packages-Built-in and User defined functions- Composition of functions-Recursion-Vectorised functions- Programming exercises with applications in Physics.

Module III (12 Hours): Conditional and Looping constructs in Python
Control flow structure- if, else-if and else-Nested condition- Looping Constructs- While and For loops- Nested loops-Break and Continue statements- Programming exercises with applications in Physics

Module IV (12 Hours): Arrays and Matrices in Python; Data visualization
Creating arrays and Matrices using functions Arrange, Linspace, Zeros, Ones, Reshape-Arithmetic operations- cross product- dot product - Matrix inversion-Saving and Restoring arrays - Programming exercises with applications in Physics.
Plotting functions- Plot, Show, Subplot, Polar and Pie functions-Plotting Sine function-Derivative of a function- Programming exercises with applications in Physics.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Practicals (30 Hours): At least 2 exercises from each module:
Calculate the solar mass, Moment of inertia about center of mass (Sphere and Cylinder), Half-life period of a radioactive material, Calculate Rydberg's constant, Newton's law of gravitation, Heisenberg's uncertainty relation, Capacitor discharge in an RC circuit, Plot relativistic and classical momentum against velocity (velocity range 0c to 0.9c, where c is the velocity of light), Planck's law – plot Planck curves', Planetary motion - plot the actual orbits of the planet for three eccentricities, Projectile motion – plot x(t) and y(t) for different values of θ, Emission lines of hydrogen atom using Rydberg's formula (wavelengths), Derivative of Sine function.

Core Compulsory Readings

1. Charles Severance, Python for Informatics

2. Wesley J Chun, Core Python Programming,Pearson Education

3. David M. Beazley, Python Essential Reference, Pearson Education

4. B S Grewal, Numerical Methods in Engineering and Science, Khanna Publishers,New Delhi

5. S.S.Shastry, Introductory methods of numerical analysis, Prentice Hall of India (1983)

Core Suggested Readings

1. Hans Petter Langtangen, A Primer on scientific Programming with Python, Springer

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and coding.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Discuss the data structure in Python
2. Explain the algorithm to find the roots of a transcendental equation
3. Analyze and debug the sample program given in Python data structure.

Semester - VI

Classical Mechanics

Course Title	:	Classical Mechanics
Semester	:	06
Course Code	:	KU06DSCPHY301
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Mechanics, Differential and Integral Calculus

Course Description:

- To provide basic and advanced concepts in classical mechanics
- To provide basic and advanced concepts in Lagrangian and Hamiltonian formulation
- This paper also gives insight to central force problems, theory of small oscillations, Kepler's problem, Rigid body dynamics and Euler's equations.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Explain the concepts of Lagrangian and Hamiltonian mechanics and use them to solve problems in mechanics.	R, U, An
2	Explain the concepts like generating functions, Poisson brackets and Hamilton-Jacobi equations.	U, An
3	Analyze the action-angle variables concepts to find the frequency of motion of the heavenly bodies.	U, An
4	Explain the theory of small oscillations and use Euler's equations of motions for rigid body dynamics.	U, A, An

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	1	-	2	-	-	-	-	-	-
CO2	3	3	1	-	2	-	-	-	-	-	-
CO3	3	3	1	-	2	-	-	-	-	-	-
CO4	3	3	1	-	2	-	-	-	-	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (18 hours)
Constraints and Generalized Coordinates; D'Alembert's Principle and Lagrange's Equations; Velocity Dependent Potentials; Simple Applications; Hamilton's Principle; Elementary Idea of Calculus of Variation; Euler-Lagrange Equation; Lagrange's Equation from Hamilton's Principle; Hamiltonian Function; Central Force Problem; Scattering in a central force field; Equivalent One-Dimensional Problem; Classification of Orbits; The Kepler Problem; Small Oscillations; Formulation of the Problem; Eigen value Equation; Normal Coordinates; Free Vibrations of a Linear Triatomic Molecule.

Module II (15 hours)
Configuration Space and Phase Space; Legendre Transformation; Hamilton's Canonical Equations; Principle of Least Action; Applications of Hamilton's Equations: Two-dimensional Isotropic Harmonic Oscillator, Charged Particle in an Electromagnetic Field; Canonical Transformations – Examples; Infinitesimal Canonical Transformation; Poisson Brackets: Properties; Equation of Motion in Poisson Bracket Form; Angular Momentum Poisson Bracket Relations.

Module III (12 hours)
Hamilton Jacobi Equation for Hamilton's Principal Function and Hamilton's Characteristic Function; Harmonic Oscillator Problem; Action Angle Variables; Hamilton Jacobi Formulation of Kepler Problem; Hamilton Jacobi Equation and Schrodinger Equation.

Module IV (15 hours)
Space Fixed and Body Fixed Systems of Coordinates; Description of Rigid Body Motion; Direction Cosines; Euler Angles; Infinitesimal Rotations; Rate of Change of a Vector; Centrifugal and Coriolis Forces; Moment of Inertia Tensor; Euler's Equation of Motion.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Core Compulsory Readings

1. Goldstein, Classical Mechanics, (3/e), Pearson Education.
2. N. C. Rana and P. S. Joag, Classical Mechanics, Tata McGraw Hill.
3. R. G. Takwale and P. S. Puranic, Introduction to Classical Mechanics, Tata McGraw Hill..
4. V. B. Bhatia, Classical Mechanics, Narosa Publishers.
5. A.J. Griffiths, Classical Mechanics, McGraw Hill.

Core Suggested Readings

1. Kiran C. Guptha, Classical Mechanics of Particles and Rigid Bodies, New Age International.

Teaching Learning Strategies

- Developing conceptual understanding

- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Distinguish between generalised coordinates and degrees of freedom.
2. Obtain Euler – Lagrange equations.
3. Explain D'Alembert's principle.
4. Obtain Hamiltonian and Hamilton Equation of motion from Lagrangian using Legendre transformation.

KANNUR UNIVERSITY

Advanced Electronics

Course Title	:	Advanced Electronics
Semester	:	06
Course Code	:	KU06DSCPHY302
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Basic Electronics

Course Description:

- This course will introduce Op-Amp and advanced electronic circuits.
- Study of registers and counters will be conducted.
- Basic principles of communication methods will be discussed.
- Microprocessor architecture will be introduced.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	1	4	3	2	5	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Understand Op-Amp characteristics and applications	R, U
2	Learn the basics of analog to digital conversion	U, An
3	Understand the operation of communication systems	U, An, E
4	Learn microprocessor architecture and various operation modes	U, A, E

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	3	1	-	2	-	-	-	-	-	-
CO2	3	3	1	-	2	-	-	-	-	-	-
CO3	3	3	1	-	2	-	-	-	-	-	-
CO4	3	3	1	-	2	-	-	-	-	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Module I (12 Hours)
Linear applications of Op-amp: Instrumentation Amplifier, Voltage to current and Current to voltage converters, differentiator, and integrator, Comparators, Schmitt Triggers. Active Filters: Low-pass, High-pass, Band-pass Band-reject filters. Oscillators: Phase Shift and Wien-bridge Oscillators, Square, Triangular and Sawtooth waveform generators. Multivibrators: Astable and monostable multivibrators.

Module II (12 Hours)
Multiplexer and Demultiplexer, Flip Flops and Timing Circuits, Different Types of Registers and Applications of Shift Registers, Counters: Synchronous Counters, Asynchronous Counters, Decade Counters and Mod 8 Ripple Counter, A/D and D/A Converters: R-2R Ladder and Successive Approximation Type ADC.

Module III (12 Hours)
Communication systems, Importance of Modulation, Amplitude Modulation, Double and Single sideband techniques, Frequency modulation and Demodulation techniques, Bandwidth requirements, Pulse Modulation: Pulse amplitude modulation (PAM), Sampling process, Performance comparison of various sampling techniques, Pulse Code Modulation (PCM), Quantization, Delta modulation, Pulse position modulation (PPM), Pulse width modulation (PWM).

Module IV (9 Hours)
Microprocessors, Microcontrollers and Microcomputers, 8085 Microprocessor, Various Operations of Microprocessors, Microprocessor Communication and Bus Timing, 8085 Bus Structure, Pin Diagram of 8085 MPU.

Module V* - Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Practicals (30 Hours): At least 6 Experiments to be performed

1. Transistor characteristics and transistor as an amplifier
2. Phase shift oscillator
3. FET characteristics and amplifier using FET
4. Voltage regulation using transistors with feedback (Regulation characteristic with load for different input voltages)
5. Two stage RC coupled amplifier (I/O resistance with and without feedback).
6. Op-Amp: Square, triangular and saw-tooth wave generator
7. Integrator and Differentiator circuits using op-amp 741
8. Low-pass, High-pass, Band pass and band reject filters using op-amp 741
9. Schmitt trigger using op-amp 741
10. Astable and monostable using op-amp 741
11. Schmitt trigger using IC 555
12. Astable and monostable using IC 555

Core Compulsory Readings

1. Ramakant A Gayakwad, Op-amps and Linear Integrated Circuits.
2. Jacob Millman & Chritos C. Halkias, Integrated Electronics.
3. Malvino & Leach, Digital Principles and Applications.
4. Dennis Roddy and John Coolen, Electronic Communications.
5. Ramesh Gaonkar, Microprocessor Architecture, Programming and Application with the 8085.
6. Paul B. Zbar and Malvine A. P., Basic Electronics, Tata McGraw Hill.
7. Begrat R. Brown J., Experiments for Electronic Devices and Circuits, Merrill International Series.
8. Buchla, Digital Experiments, Merrill International Series.
9. Jain R.P. and Anand M.M.S., Digital Electronics Practice Using ICs, Tata McGraw Hill.
10. Subramanian V. S., Experiments in Electronics, McMillan.
11. Poorna Chandra Rao and Sasikala B., Hand Book of Experiments in Electronics and Communication Engineering.

Core Suggested Readings

1. J. Millman, C. C. Halkias and S. Jit. Electronic devices and circuits

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Design and construct an inverting amplifier using op-amp 741.
2. Design and construct a non-inverting amplifier using op-amp 741.
3. Design and construct a first order low pass filter.

Modern Optics

Course Title	:	Modern Optics
Semester	:	06
Course Code	:	KU06DSCPHY303
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Fundamentals of Optics

Course Description:

- To study theory, construction, working and different applications of Lasers.
- To understand the theory, construction, working and different application of optical fibers.
- Understand nonlinear optical phenomena like second harmonic generation, parametric amplification, self focusing etc.
- Understand the basics of Holography

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	1	4	3	2	5	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Explain the basics of LASER, the working principle of different varieties of LASERS, and their applications.	U, An
2	Describe the propagation of light through optical fiber, the relation between Numerical Aperture and Refractive indices, the types of optical fibers, and the attenuation mechanism.	U, An
3	Describe the basic principles and applications of holography	U, An, E
4	Illustrate nonlinear optics and explain the Harmonic generation, parametric amplification etc.	U, A, An

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	3	1	-	2	-	-	-	-	-	-
CO2	3	3	1	-	2	-	-	-	-	-	-
CO3	3	3	1	-	2	-	-	-	-	-	-
CO4	3	3	1	-	2	-	-	-	-	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (15 Hours)
Introduction to lasers: Interaction of light with matter-Einsteins coefficients and their relations-light amplification, cavity, gain medium, rate equations, population inversion, lasing condition, level lifetime, spontaneous and stimulated emission. Dephasing time, line broadening mechanisms: homogeneous and inhomogeneous broadening, hole burning, spatial hole burning; examples of lasing systems: DFB and DBR lasers, semiconductor lasers, He-Ne laser, Raman laser, Brillouin laser, mode-locked lasers, Vertical Cavity Surface Emitting Lasers (VCSELs).

Module II (9 Hours)
Fibre optics: Optical fibre, Total internal reflection, Propagation of light through optical fibre; Fractional refractive index; Numerical aperture; Classification of optical fibres; The three types of fibres; Applications; Fibre optic communication system; Merits of optical fibres.

Module III (9 Hours)
Holography: Principle of holography; Recording and reconstruction; Holograms; Holograhy and photography; Important properties of holograms; Applications.

Module IV (12 Hours)
Nonlinear Optics: Linear and Nonlinear Polarization, Wave Equation with driving polarization; Second and Third-order optical nonlinearities, Parametric vs non-parametric process; Intensity dependent refractive index; Introduction to four-wave mixing, Third harmonic generation, Phase matching techniques, Stimulated Raman Scattering, Stimulated Brillouin scattering, Electromagnetically Induced Transparency.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Practicals (30 Hours): At least 6 Experiments to be performed

1. Cauchy's constants – Determination of Cauchy's constants of sodium light.
2. Laser – Diameter of a thin wire.
3. Laser – Determination of slit width.
4. Cornu's hyperbolic fringes – Determination of Y, σ and K with Pyrex.
5. Cornu's elliptical fringes – Determination of Y, σ, K with glass.
6. Photo diode characteristics: To study the output characteristics of a photo diode
7. Solar cell – Spectral response and I-V characteristics
8. Ultrasonic Interferometer – To determine the velocity of ultrasonic waves in the given liquids
9. Optical fibre cable - Numerical aperture.
10. Optical fibre cable - divergence angle and attenuation.

Core Compulsory Readings

1. Ajoy Ghatak, Optics (6/e), McGrawHill (2017)
2. Ajoy Ghatak & K. Thyagarajan, Introduction to Fiber Optics, Cambridge University Press (2018)
3. Robert Boyd, Nonlinear Optics (3/e), Elsevier (2009)

Core Suggested Readings

1. M. Born & E. Wolf, Principles of Optics, Cambridge University Press (1999)

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Discuss population inversion and explain lasing in a gain medium.
2. Explain total internal reflection.
3. Discuss the principles of Holography.
4. Differentiate between parametric and non-parametric processes.

Introduction to Nanomaterials

Course Title	:	Introduction to Nanomaterials
Semester	:	06
Course Code	:	KU06DSEPHY301
Course Type	:	DSE
Course Credits	:	4
Pre-requisites	:	Introduction to Solid state physics

Course Description:

- This course introduces the students to the world of nanomaterials.
- Physical and chemical properties of nanoparticles will be discussed.
- Quantum confinement effects and plasmon resonance will be illustrated through examples.
- Surface effects and energy minimization methods will also be discussed.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Explain the history and basics of nanomaterial research.	U, An
2	Describe size and shape dependent properties of nanoparticles	U, An
3	Learn and analyze the plasmonic response of nanomaterials	U, An, E
4	Understand various surface effects and surface energy stabilization mechanisms.	U, An E

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	3	1	-	2	-	-	-	2	3	-
CO2	3	3	1	-	2	-	-	-	2	3	-
CO3	3	3	1	-	2	-	-	-	2	3	-
CO4	3	3	1	-	2	-	-	-	2	3	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (15 Hours)
Fundamentals of Nanomaterials, History of Nanotechnology, Feynman's vision on Nano Science & technology, bulk vs nanomaterials. Central importance of nanoscale morphology - small things making big differences, nanotechnology as natures technology, clusters and magic numbers. nanoscale architecture. Recent developments, challenges and future prospects of nanomaterials.

Module II (15 Hours)
Size and shape dependent properties of nanomaterials Size and shape dependent properties, Melting points and lattice constants. Surface Tension, density of states, Wettability - Specific Surface Area and Pore - Composite Structure -Mechanical properties. Optical properties: Basic principles of nanomaterials- increase in surface area to volume ratio and quantum confinement effect. Surface Plasmon resonance in metal nanoparticles and quantum size effect in Semiconductors, Electrical conductivity: Surface scattering, change of electronic structure, quantum transport. effect of microstructure.

Module III (15 Hours)
Classification of nanomaterials: Classification based on the dimensionality. Zero-dimensional nanostructures: metal,semiconductor and oxide nanoparticles. One-dimensional nanostructures: nanowires and nanorods. two-dimensional nanostructures: thin films. Three-dimensional nanomaterials. Special Nanomaterials: Carbon fullerenes and carbon nanotubes. micro and mesoporous materials. core-shell structures. organic-inorganic hybrids.

Module IV (15 Hours)
Surface science for nanomaterials, surface energy, Surface Energy minimization: Sintering Ostwald ripening and agglomeration. Energy minimization by Isotropic and anisotropic surfaces. Wulff plot, Surface energy, surface curvature and chemical potential. Surface energy stabilization mechanisms. Electrostatic stabilization - Point zero charge (p.z.c).Nernst Equation. Electric double layer. Electric potential at the proximity of a solid surface - Debyo-tluckcl Screening strength. Interaction between nanoparticles - Van der Waals attraction potential. DLVO Theory. static stabilization and electro static stabilization. Nucleation and growth of nuclei. critical radius, homogenous and heterogeneous nucleation.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Core Compulsory Readings

1. A.W. Adamson and A.P.Cast, Physical Chemistry of surfaces, Wiley lnterscience. NY (2004).
2. G. Cao and Y. Wang, Nanostructures and Nanomaterials, 2nd Ed., lmperial College Press (2004).
3. R. Kelsall. L Hamley and M. Ceoghegan, Nanoscale Science and Technology, Wiley (2005).
4. K. J. Klabunde. R. M. Richards, Nanoscale Materials in Chemistry (2/e), Wiley (2009).

5. T. Pradeep, A text book of Nano Science and Technology, Tata McGraw-Hill Education (2012).

Core Suggested Readings

1. G. Schmidt. Nanoparticles: From Theory to applications. Wiley-VCH (2004)
2. Malkiat S. Johal, Lewis E. Johnson, Textbook Series in Physical Sciences, CRC Press (2008)
3. G. Cao, Nanostructures & Nanomaterials; Synthesis, Properties & Application, Imperial College Press, 2004.

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Describe the basic characteristization methods for nanomaterials.
2. Explain the plasmonic response of a nanoparticle

Energy Physics

Course Title	:	Energy Physics
Semester	:	06
Course Code	:	KU06DSEPHY302
Course Type	:	DSE
Course Credits	:	4
Pre-requisites	:	Introduction to Solid state physics

Course Description:

- Main aim of the course is to provide basic knowledge on Energy resources and the need for conservation of energy.
- To make the students acquire an awareness of Solar energy, solar energy conversion and importance of solar energy in the present scenario.
- It is intended to help them grasp a broad outline of different energy sources like ocean energy, wind energy etc.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Understand Energy policy perspectives.	U, An
2	Classify technologies for conversion of solar energy resouces.	U, An
3	Illustrate Photovoltaic conversion mechanism.	U, An, E
4	Explore various modes for ocean energy conversion.	U, An E

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	3	1	-	2	-	-	-	2	3	-
CO2	3	3	1	-	2	-	-	-	2	3	-
CO3	3	3	1	-	2	-	-	-	2	3	-
CO4	3	3	1	-	2	-	-	-	2	3	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (18 Hours)
Overview of world energy scenario; Energy Demand- present and future energy requirements; Review of conventional energy resources - Coal, gas and oil reserves, Tar sands and Oil Shale, Nuclear energy; Global warming; Green House Gas emissions, impacts,mitigation; sustainability; United Nations Framework Convention on Climate Change (UNFCCC); Sustainable development; Kyoto Protocol; Conference of Parties (COP); Clean Development Mechanism (CDM); Prototype Carbon Fund (PCF).

Module II (18 Hours)
Solar Energy -Solar radiation, its measurements and prediction; Solar thermal collectors- flat plate collectors, concentrating collectors; solar heating of buildings; solar still; solar water heaters; solar dryers; conversion of heat energy in to mechanical energy, solar thermal power generation systems. Photovoltaic Conversion -intrinsic, extrinsic and compound semiconductor; Absorption of light; Recombination process; p-n junction: homo and hetero junctions; Dark and illumination characteristics; Principle of photovoltaic conversion of solar energy, Figure of merits of solar cell; Efficiency limits.

Module III (15 Hours)
Wind Energy -Wind energy conversion principles; General introduction; Power, torque and speed characteristics. Atmospheric circulations; factors influencing wind, wind shear,turbulence, wind speed monitoring; Betz limit; Tlpes and classification of WECS, characteristics and applications.
Module IV (9 Hours)
Ocean Energy - Ocean energy resources, ocean energy routes; Principles of ocean thermal energy conversion systems; ocean thermal power plants; Principles of ocean wave energy conversion and tidal energy conversion.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Core Compulsory Readings

1. B H Khan, Non- conventional energy resources, , Tata McGraw-Hill Publication (2006).
2. John Twidell and Tony Weir, Renewable Energy Resources, Routledge, Taylor& Francis (2015).
3. Chetan Singh Solanki, Solar Photovoltaics: Fundamentals, Technologies And Applications, PHI Learning (2015).

Core Suggested Readings

1. G. D. Rai, Non-Conventional Energy Resources, Khanna Publishers (2008).
2. L.L. Freris, Wind Energy Conversion Systems, Prentice Hall, (1990).
3. Renewable Energy, Bent Sorensen (2/e), Academic press, (2000).

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Describe the basic characteristics of a solar cell.
2. Explain the photovoltage generation process.
3. Discuss thin film solar cell technologies.

Quantum Mechanics

Course Title	:	Quantum Mechanics
Semester	:	07
Course Code	:	KU07DSCPHY401
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Quantum Physics, Classical Mechanics

Course Description:

- Hibert space formulation of the basic principles and the equation of motion are established.
- Concepts of linear vector spaces, matrices and the theory of angular momentum is given in a more detailed way.
- A unified view of the different formulation of non-relativistic quantum mechanics is established.
- Schrodinger's and Heisenberg's formulations appear merely as different representations, analogous respectively to the Hamilton-Jacobi theory and Hamilton's formalism in classical mechanics.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Explain the concepts of Linear vector space and the representation of vectors and operators in matrix form.	R, U, An
2	Describe the fundamental postulates of quantum mechanics and the concept of physical observable, and measurement of the complex state.	U, An
3	Explain the basic concepts of quantum dynamics. Describe different pictures like Schrodinger,Heisenberg and the interaction pictures.	U, An
4	Explain the quantum theory of angular momentum and use angular momentum algebra for physical systems by determining eigenvalues and eigenvectors associated with angular momentum.	U, A, An

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	1	-	2	-	-	-	-	-	-
CO2	3	3	1	-	2	-	-	-	-	-	-
CO3	3	3	1	-	2	-	-	-	-	-	-
CO4	3	3	1	-	2	-	-	-	-	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (18 hours)
Linear Vector Space, Ortho Normal Basis, Unitary Space, Hilbert Space, Completeness, Closure Property, Operators: Different Types, Commuting operators, Dirac Notation, Matrix Representation of Vectors, Operators and Bases, Unitary Transformations, Change of Basis, Coordinate and Momentum Representation, Fundamental Postulates, The Equation of Motion, Schrodinger Pictures, Heisenberg Pictures, Interaction pictures, Uncertainty Principles, Time Energy Uncertainty Relation, Linear Harmonic Oscillator in Schrodinger and Heisenberg Pictures.

Module II (18 hours)
Definition of Angular Momentum, Eigen Values and Eigen Vectors, Angular Momentum Matrices, Pauli Spin Matrices, Orbital Angular Momentum, Angular Momentum and Rotation, Euler Angle, Addition of Angular Momentum, Clebsch Gordan Coefficients, Theory of Hydrogen Atom.

Module III (12 hours)
Space-time Symmetries, Displacement in Space and Time, Space Rotation, Space Inversion, Time Reversal, Identical Particles, Symmetric and Antisymmetric Wave Functions, Pauli's Exclusion Principle – Spin and Statistics, Two Electron Systems – Helium Atom.

Module IV (12 hours)
Variational Method for Bound States – Ground state of Helium Atom, Time Independent Perturbation Theory, Non-degenerate Case – Anharmonic Oscillator, Degenerate case – Stark and Zeeman Effects in Hydrogen Atom.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Core Compulsory Readings

1. V. K. Thankappan, Quantum Mechanics, Wiley Eastern.
2. Ghatak and Lokanathan, Quantum Mechanics, MacMillan
3. Zettili, N, Quantum Mechanics: Concepts & Applications (2/e), Wiley (2009).
4. Griffiths, D J, Introduction to Quantum Mechanics, Pearson Education (2005).

Core Suggested Readings

1. Bransden and Joachain, Introduction to Quantum Mechanics, ELBS.
2. G. Aruldas, Quantum Mechanics, PHI.

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Explain uncertainty principle.
2. Describe interaction picture for harmonic oscillator.
3. Explain Zeeman effect on the basis of quantum mechanics.
4. Explain the time independent perturbation theory.
5. Describe the concept of time reversal.
6. List the fundamental postulates of quantum mechanics

Mathematical Physics II

Course Title	:	Mathematical Physics II
Semester	:	07
Course Code	:	KU07DSCPHY402
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Mathematical Physics I

Course Description:

- This course aims to equip the students with the mathematical skill to solve problems in advanced physics.
- To provide basic and advanced concepts in Fourier series, Fourier and Laplace transforms, Applications of Fourier and Laplace problems in physical problems.
- This paper also gives insights to Green's functions for solving differential equations, integral equations, Green's functions, theory of groups and chaos.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Develop analytical skills to solve problems in different areas of physics using Fourier series, Fourier and Laplace transforms .	R, U, An
2	Use Laplace transform to solve differential equations.	U, An
3	Illustrate and apply concepts of group theory in physics problems.	U, An
4	Use the method Green's function to solve non-homogeneous linear differential equations.	U, A, An

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	3	-	-	2	-	-	-	-	-	-
CO2	3	3	-	-	2	-	-	-	-	-	-
CO3	3	3	-	-	2	-	-	-	-	-	-
CO4	3	3	-	-	2	-	-	-	-	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (15 hours): Fourier Series and Integral Transforms
Fourier Series: General properties and Applications, Integral Transforms: Fourier Transform and Properties - Fourier Transform of Derivatives - Convolution Theorem, Laplace Transform and Properties - Laplace Transform of Derivatives - Convolution Theorem - Inverse Laplace Transform - Laplace Convolution Theorem.

Module II (15 hours): Complex Variable Theory
Function of Complex Variables: Introduction- Argand diagram, Analytic Function - Cauchy - Riemann Conditions- Derivatives of a analytic function, Conformal Mapping, Cauchy's Integral Theorem: Contour Integrals- Caushy's theorem and proof, Multiply Connected Regions, Cauchy's Integral Formula - Derivatives - Morera's Theorem - Cauchy's inequality - Taylor series and theorem, Laurent series and Theorem, Singularities - poles - meromorphic - entire functions- Branch point, Calculus of Residues- Residue Theorem, Evaluation of Definite Integrals.

Module III (15 hours): Integral Equations and Green Functions
Integral Equations: Transformation of a Differential Equation into an Integral Equation - Integral Transforms and Generating Function methods - Separable Kernel - Neumann Series - Hilbert-Schmidt Theory, Green's function: Properties - One Dimensional Green's Function - Problems - Eigenfunction Expansion.

Module IV (15 hours): Group Theory
Groups: Definition and Examples, Representation of Group: - Multiplication Table - Consequences -Symmetry Group of Square and Triangle - Permutation Group - Subgroups - Direct Product Groups - Isomorphism and Homomorphism - Cyclic Group - Factor Group Representation of a Group - Types of Representation - Schur's Lemmas - Orthogonality Theorem and Proof Geometrical Interpretation - Character of a Representation Character Table Basic Ideas of Continuous Groups - SU(2) and SU(3) Groups.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Core Compulsory Readings

1. G.B.Arfken and H.J.Weber, Mathematical Methods for Physicists (6/e), Academic Press (2005)
2. A. W. Joshi, Group Theory for Physicists, Wiley Eastern.
3. Michel Tabor, Chaos and Integrability in Nonlinear Dynamics, Wiley Easte
4. Pipes and Harvill, Applied Mathematics for Physicists and Engineers, McGraw Hill.
5. Sathyaprakash, Mathematical Physics, S. Chand & CO

Core Suggested Readings

1. K. F. Riley and Hobson, Mathematical Methods for Physicists and Engineers, Cambridge.

2. R. Courant and D. Gilbert, Methods of Mathematical Physics, Wiley Eastern

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Find the Fourier transform of the function $f(t) = sin(3t)/t$.
2. Explain how Green's function relates to integral equations.
3. Describe Lie groups
4. Illustrate the representation of a group.
5. Explain the method of plotting logistic maps.

Statistical Mechanics

Course Title	:	Statistical Mechanics
Semester	:	07
Course Code	:	KU07DSCPHY403
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Classical and Quantum Physics

Course Description:

- This course aims at explaining the physical properties of matter in bulk on the basis of the dynamical behavior of its microscopic constituents.
- The paper brings macroscopic and microscopic worlds into a common formulation and introduces ensemble formalism.
- The basic ideas of quantum statistical mechanics and fundamentals of Ising theory will also be demonstrated.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Explain the macroscopic phenomena (any natural phenomena) in terms of the microscopic parameters or to bridge the microscopic and macroscopic worlds.	R, U, An
2	Elucidate the connection between the thermodynamic and statistical parameters.	U, An
3	Describe the different ensemble formalism and differentiate micro canonical, canonical and grand canonical ensembles.	U, An
4	Apply statistical mechanics as a tool to solve various physical situations related to classical and quantum mechanical systems with specific examples like Bose Einstein Condensation and black body radiation.	U, A, An

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	3	1	-	2	-	-	-	-	-	-
CO2	3	3	1	-	2	-	-	-	-	-	-
CO3	3	3	1	-	2	-	-	-	-	-	-
CO4	3	3	1	-	2	-	-	-	-	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (15 hours) : Statistical Basis of Thermodynamics and Elements of Ensemble Theory

The macroscopic and microscopic states - Boltzmann relation between entropy and microstates - Connection between statistics and thermodynamics, Classical ideal gas, Gibbs paradox - The correct enumeration of microstates, Phase space, Liouville's theorem and its consequences, The microcanonical ensemble - Examples of calculation of microstates -Classical ideal gas -Simple Harmonic oscillator.

Module II (18 hours): Canonical and Grand Canonical Ensemble Theory

Canonical Ensemble: Equilibrium between a system and reservoir- A system in the canonical ensemble - method of most probable values - Physical significance of statistical quantities in the canonical ensemble - Partition function for non - degenerate and degenerate systems - Density of states - The classical systems - Energy fluctuation in canonical ensemble - correspondence with the microcanonical ensemble, Equipartition theorem and virial theorem, A system of harmonic Oscillators. Grand Canonical Ensemble:Equilibrium between a system and a particle - energy reservoir, A system in Grand canonical ensemble - Physical Significance of statistical quantities - Examples in grand canonical ensemble, Classical ideal gas, a system of independent localised particles - Harmonic Oscillators, density and energy fluctuations in grand canonical ensemble correspondence with other ensembles.

Module III (15 hours): Quantum Statistics

Limits of Classical Statistics - Quantum Statistics - Density of states - Bose - Einstein statistics - Fermi - Dirac statistics, An ideal gas in quantum mechanical micro canonical ensemble - An ideal gas in other quantum mechanical ensembles - Statistics of occupation numbers, Thermodynamic behaviour of an ideal Bose gas - Bose-Einstein condensation - Thermodynamics of the blackbody radiation, Thermodynamic behaviour of an ideal Fermi gas - Fermi temperature and Fermi energy - Magnetic behaviour of ideal Fermi gas - Pauli paramagnetism - Landau diamagnetism, Electron gas in metals.

Module IV (12 hours): Phase Transition

Dynamical model of phase Transition, Lattice gas and binary alloys, Ising model in Zeroth approximations, Ising model in First approximation, critical exponents,Thermodynamic inequalities, Landau phenomenological Theory.

Module V*: Teacher Specific Module:

Area of content, transaction and evaluation are decided by the Faculty.

Core Compulsory Readings

1. R K Pathria, Paul D. Beale - Statistical Mechanics (4/e), Academic Press (2022)
2. Roger Bowley, Mariana Sánchez - Introductory Statistical Mechanics (2/e), Oxford University Press (2000)
3. Kerson Huang, Statistical Mechanics (2/e), John Wiley and Sons
4. Reif, Statistical Physics: Berkeley Physics Course Vol. 5, Tata Mcgraw Hill (2011).

Core Suggested Readings

1. Mandl, Statistical Physics (2/e), John Wiley & Sons (1991).

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Describe macrostate and microstates.
2. State and explain Lioville's theorem.
3. Explain Gibb's paradox.
4. Obtain expression for probability of seeing a system in a canonical ensemble with energy E.
5. Explain the density fluctuation in grand canonical ensemble.
6. Describe Ising model.

Photovoltaic Energy Conversion

Course Title	:	Photovoltaic Energy Conversion
Semester	:	07
Course Code	:	KU07DSEPHY401
Course Type	:	DSE
Course Credits	:	4
Pre-requisites	:	Condensed matter physics

Course Description:

- This course introduces the basics of photovoltaic energy conversion.
- To study theory, construction, working and different applications of solar cells.
- This course helps to understand various thin film solar cell technologies.
- Solar photovoltaic modules are also discussed.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	1	4	3	2	5	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Explain the basics of photovoltaic energy conversion.	U, An
2	Describe depletion layer formation and light matter interaction in a pn junction	U, An
3	Learn and analyze the basic characteristics of solar cells	U, An, E
4	Understand various solar cell technologies and investigate the current trends	U, An E

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	3	1	-	2	-	-	-	2	3	-
CO2	3	3	1	-	2	-	-	-	2	3	-
CO3	3	3	1	-	2	-	-	-	2	3	-
CO4	3	3	1	-	2	-	-	-	2	3	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (9 Hours)
Solar Energy – The Solar Constant – Solar Intensity on Earth's Surface – Direct and Diffuse Radiation – Apparent Motion of Sun – Solar Insolation Data.

Module II (12 Hours)
p-n Junction I-V Relation: Quantitative Analysis – p-n Junction under Illumination: Generation of Photo Voltage(PV) and Light Generated Current – I-V Equation for Solar Cells – Solar Cell Characteristics. Design of Solar Cells:Upper Limit of Solar Cell Parameters: Short Circuit Current, Open Circuit Voltage, Fill Factor and Efficiency –Losses in Solar Cells – Model of Solar Cells – Effect of Series and Shunt Resistance – Solar Radiation and Effect of Temperature on Solar Cell Efficiency – Solar Cell Design – Design for High Short Circuit Current – Choice of Junction Depth and Orientation – Minimization of Optical Losses and Recombination – Design for High Open Circuit Voltage –Design for High Fill Factor.

Module III (12 Hours)
Thin Film Solar Cell Technologies: Generic Advantages of Thin Film Technologies –Materials for Thin Film Technologies – Thin Film Deposition Techniques – Common Features of Thin Film Technology – Amorphous Si Solar Cell Technology – Cadmium Telluride Solar Cell Technology – Thin Film Crystalline Solar Cells.

Module IV (12 Hours)
Solar Photovoltaic Applications: Solar Photovoltaic (SPV) Modules – SPV from Solar Cells – Series and Parallel Connections – Mismatch in Cell Module – Mismatch in Series Connection – Hot Spots in Modules – Bypass Diode– Mismatch in Parallel Connection – Design and Structure of PV Modules – Number of Solar Cells – Wattage of Modules – PV Module Power Output – I-V Equation for PV Modules – I-V and Power Curves of Module – Effect of Solar Irradiation and Temperature.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Practicals (30 Hours): At least 6 Experiments to be performed

1. Prepare a metal thin film using physical deposition technique.
2. To study the optical, structural, and surface morphological properties of the thin film provided.
3. Measure the change in in-plane and out-of-plane conductivity of a thin film with thickness.
4. From the given XRD data find the strain and particle size.
5. Using the given absorbance spectra of the dye find the degradation rate.
6. Study the Characteristics of Solar cell
7. Using PV system using a ready made PV cells, DC ammeter to find how wavelength of the light affect the electricity production

8. From the given data of doped semiconductors find the absorption coefficient and variation in optical band gap.

Core Compulsory Readings

1. Chetan Singh Solanki, Solar Photovoltaic: Fundamentals, Technologies and Applications, PHI, 2nd Edn,
2. G. Busch and Schade, Lectures on Solid State Physics, Pergamon Press.
3. B. O. Seraphin, Solar energy conversion, Springer.
4. S. R. Das and K. L. Chopra, Thin Film Solar Cells, Springer.

Core Suggested Readings

1. Harold J. Hovel, Semiconductors and Semimetals-Vol.II, Academic Press.
2. Martin A. Green, Solar Cells, Prentice Hall Series.
3. Tom Markvart and Luis Castner, Handbook of Solar Cells, Springer.

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Describe the basic characteristics of a solar cell.
2. Explain the photovoltage generation process.
3. Discuss thin film solar cell technologies.
4. List out the advantages of CdTe solar cell technology.

Fiber Optics

Course Title	:	Fiber Optics
Semester	:	07
Course Code	:	KU07DSEPHY402
Course Type	:	DSE
Course Credits	:	4
Pre-requisites	:	Electromagnetic Theory

Course Description:

- This course introduce the fiber optics technology.
- Concepts of optical waveguiding will be discussed.
- Concepts of optical modes and chromatic dispersion will be explained.
- Dispersion management in optical communication systems will be discussed.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	1	4	3	2	5	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Remember th concepts of total internal reflection and understand the importance of optical communication.	R, U
2	Explain the concepts of optical waveguiding and analyze supported modes.	U, An
3	Illustrate the mode propagation and evaluate the loss factors to minimize signal broadening	U, An, E
4	Explore various fiber optic technologies and learn loss compensation	U, A, E

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	3	2	2	1	1	-	-	2	1	-
CO2	3	3	2	2	1	1	-	-	2	1	-
CO3	3	3	2	2	1	1	-	-	2	1	-
CO4	3	3	2	2	1	1	-	-	2	1	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (12 Hours)
Introduction, need for optical communication, salient features of optical fibers, ray theory of light guidance, numerical aperture, modes of a fiber, single and multimode fibers, step-index and graded-index fibers, fiber fabrication techniques Transmission characteristics of optical fibers, attenuation, pulse broadening mechanism, intermodal dispersion, bit rate - length product, material dispersion, electromagnetic wave analysis of light propagation in an infinitely extended medium, em waves in dielectrics, boundary conditions.

Module II (12 Hours)
Electromagnetic analysis of planar optical waveguides, TE and TM modes, planar mirror waveguide, dielectric symmetric step- index, planar waveguide, symmetric and anti-symmetric modes, b-V curves, modal fields Power associated with modes of dielectric symmetric planar waveguide, asymmetric planar waveguide, single polarization single mode waveguide, excitation of guided modes by prism coupling technique, radiation modes, optical fiber waveguide, EH and HE modes, weakly guiding fibers, LP modes, mode cut-offs, b-V curves.

Module III (9 Hours)
Optical fiber modes, field patterns, degeneracies, fractional power in the core, single mode fiber, cut-off wavelength, mode field diameter, bend loss, splice loss, waveguide dispersion, group delay Total chromatic dispersion, pulse broadening and chirping, dispersion in graded-index and multilayer fibers, optical fiber components and devices, directional coupler, power splitter, WDM coupler, polarization controllers, fiber Bragg gratings.

Module IV (12 Hours)
Various types of fiber Bragg gratings, fabrication methods, applications, long period gratings, optical fiber amplifier, erbium doped fiber amplifier, dispersion management, dispersion shifted fiber, dispersion compensating fiber, sources for optical fiber communication, light emitting diode, internal and external quantum efficiencies, LED characteristics, laser diode Detectors for optical communication, p-i-n photodetector, APD, System design, dispersion and attenuation limited systems, BER, power budgeting of fiber link, recent advances .

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Practicals (30 Hours): At least 6 Experiments to be performed

1. Measurement of numerical aperture
2. Measurement of spectral attenuation
3. Measurement of fiber loss
4. Characterization of detectors for optical fiber systems
5. Characterization of sources for optical fiber systems
6. Wavelength multiplexing in an optical fiber
7. Optical link design

8. Fiber parameters by scattering measurements
9. Optical fiber acoustic sensor
10. Holographic coupler for fibers
11. Analog link using optical fiber
12. Voice link using optical fiber
13. PAM signal transmission & reception
14. Propagation loss measurement
15. Bending loss measurement

Core Compulsory Readings

1. Ghatak A & Thyagarajan K, Introduction to Fiber Optics, Cambridge University Press (1998)

Core Suggested Readings

1. Capri A. Z. and Pant P.V., Introduction to Electromagnetics, Narosa Publications.
2. John R. Reitz, Frederic J. Milford and Robert W. Christy, Foundations of Electromagnetic Theory, Narosa Publications.
3. David. J. Griffiths, Introductions to Electrodynamics (4/e), Prentice Hall.
4. Laud B. B, Electromagnetics (3/e), Wiley Eastern.
5. Chopra K. K. and Agarwal G. C., Electromagnetic Theory (4/e), K. Nath and Co., Meerut.

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

<table>
<tr><th colspan="3">Assessment Rubrics</th><th>Total</th></tr>
<tr><td>End Semester Evaluation</td><td>External Test</td><td>50</td><td>50</td></tr>
<tr><td rowspan="4">Continuous Evaluation</td><td>Internal Exams</td><td>20</td><td rowspan="4">50</td></tr>
<tr><td>Assignments</td><td>10</td></tr>
<tr><td>Seminar</td><td>10</td></tr>
<tr><td>Viva</td><td>10</td></tr>
</table>

Sample Questions to test Outcomes

1. Describe optical fiber technology.
2. Discuss total internal reflection.
3. Discuss symmetric and asymmetric planar waveguides

Thin Film Technology

Course Title	:	Thin Film Technology
Semester	:	07
Course Code	:	KU07DSEPHY403
Course Type	:	DSE
Course Credits	:	4
Pre-requisites	:	Solid state physics, Electromagnetic theory - I

Course Description:

- This course explains the theory of thin film formation and various factors that affect the structure of thin films.
- Expert training in different thin film fabrication and characterization techniques will be provided.
- This course also covers important properties and application of thin films.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	1	4	3	2	5	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Explain the basics of thin films, the theory of thin film formation, and the various factors affecting the structure of thin films.	R, An
2	Illustrate the different techniques for thin film fabrication like vacuum evaporation, pulsed laser ablation, sputtering, chemical vapor deposition etc.	U, An
3	Describe how to measure the thickness of thin films and explain the different characterization techniques like XRD, Uv-Vis spectroscopy, SEM, TEM etc and study its theory, construction and working in detail.	U, An, E
4	Describe different applications of thin films in technology and daily life.	U, A, E

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	3	1	-	2	-	-	-	-	-	-
CO2	3	3	1	-	2	-	-	-	-	-	-
CO3	3	3	1	-	2	-	-	-	-	-	-
CO4	3	3	1	-	2	-	-	-	-	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (12 Hours)
Thin Film Physics: Mechanism of Thin Film Formation, Formation Stages of Thin Films, Condensation and Nucleation, Thermodynamic Theory of Nucleation, Growth and Coalescence of Islands, Influence of Various Factors on the Final Structure of Thin Films, Crystallographic Structure of Thin Films.

Module II (12 Hours)
Methods of Preparation/Synthesis of Thin Films: Vacuum Evaporation, Resistive Heating, Electron Beam Evaporation and Laser Beam Evaporation, Sputtering: Glow Discharge, Radio Frequency and Magnetron Sputtering, Chemical Methods: LCVD, PCVD and PECVD, Spray Method: Spray Hydrolysis and Spray Pyrolysis, Langmuir Blochet Technique, Sol-gel Deposition. Thickness Measurements, Resistance,Capacitance, Microbalance, Quartz Crystal Thickness Monitor, Optical Absorption, Multiple Beam Interference, Interference Colour and Ellipsometry Methods.

Module III (9 Hours)
Characterization/Analysis of Materials and Devices (Basic Principles), X-Ray Diffraction (XRD), Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM), Energy Dispersive Analysis of X-rays (EDAX),UV-VIS Spectroscopy, Fourier Transform Infrared (FTIR) Spectroscopy, Electron Spin Resonance (ESR), X-ray Photoelectron Spectroscopy (XPS).

Module IV (12 Hours)
Scanning Tunneling Microscopy(STM), Atomic Force Microscopy (AFM), Applications: Thin film resistors, Materials and Design of thin film resistors (Choice of resistor and shape and area), Trimming of Thin Film resistors, Sheet Resistance Control, Individual Resistor Trimming, Thin Film Capacitors, Thin Film Field Transistors, Fabrication and Characteristics, Thin Film Diodes.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Practicals (30 Hours): At least 6 Experiments to be performed

1. Prepare a metal thin film using physical deposition technique.
2. To study the optical, structural, and surface morphological properties of the thin film provided.
3. Measure the change in in-plane and out-of-plane conductivity of a thin film with thickness.
4. From the given XRD data find the strain and particle size.
5. To find the average grain/crystallite size, unit cell parameters, micro-strain by recording the X-ray diffraction pattern of the given sample.
6. Using the given absorbance spectra of the dye find the degradation rate.

7. Using PV system using a ready made PV cells, DC ammeter to find how wavelength of the light affect the electricity production
8. From the given data of doped semiconductors find the absorption coefficient and variation in optical band gap.

Core Compulsory Readings

1. Maisel L. L and Glang R., HandBook of Thin Film Technology, McGraw Hill (1970)
2. Chopra K. L., Thin Film Phenomena, McGraw Hill (1969).
3. Goswami A., Thin Film Fundamentals, New Age Intemational Ltd. (1996).

Core Suggested Readings

1. Joy George, Preparation of Thin Films, Dekker.
2. Khangaonkar P. R., An Introduction to Materials Characterization, Pen ram International Publishing.

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Explain the percolation limit of thin film formation.
2. Discuss various surface topography techniques.
3. Compare thermal evaporation and sputtering.

Semiconducting Materials & Devices

Course Title	:	Semiconducting Materials & Devices
Semester	:	07
Course Code	:	KU07DSEPHY404
Course Type	:	DSE
Course Credits	:	4
Pre-requisites	:	Solid state physics, Electromagnetic theory - I

Course Description:

- The course provides a description of basic and advanced level properties of semiconductor materials as well as their functioning in some of the applications.
- Students will learn the physical behaviour of bipolar junction transistors and field effect transistors by forming semiconductor junctions.
- The principle and working of optoelectronic devices such as solar cells, photodetectors, light emitting diodes etc. will also be elaborated.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Explain the basic and advanced properties of semiconductor materials.	R, An
2	Describe the importance of semiconductor materials in various device applications.	U, An
3	Illustrate working of bipolar junction transistors and field effect transistors on a semiconductor perspective.	U, An, E
4	Describe the principle and working of optoelectronic devices such as solar cells, photodetectors, light emitting diodes etc.	U, A, E

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	3	1	-	2	-	-	-	-	-	-
CO2	3	3	1	-	2	-	-	-	-	-	-
CO3	3	3	1	-	2	-	-	-	-	-	-
CO4	3	3	1	-	2	-	-	-	-	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (15 Hours)
Carrier Drift, Drift Current Density, Mobility Effects, Conductivity, Velocity Saturation, Carrier Diffusion, Diffusion Current Density, Total Current Density, Graded Impurity Distribution, Induced Electric Field, The Einstein Relation, Reciprocal Lattice, Bragg Reflection of Electron Waves, Brillouin Zones, Important Features of Energy Bands of Si, Ge and GaAs

Module II (15 Hours)
Intrinsic, Extrinsic and Compensated Semiconductors, Electrons and Holes: Semiconductor Statistics, Electron and Hole Mobilities and Drift Velocities, Hall Effect and Magneto resistance, Quasi Fermi Levels:Generation and Recombination of Carriers, p-n Junction under Zero Bias Condition, Depletion Capacitance, Diffusion Capacitance, Tunneling and Tunnel Diodes, Junction Breakdown, Schottky Barriers, Ohmic Contacts.

Module III (15 Hours)
Bipolar Junction Transistor: Principle of Operation, Doping Profile, Electron Diffusion Current in the Base, BJT as a Switch, Bipolar Transistors in Integrated Circuits, FET: Basic Principles, Surface Charge in Metal Oxide Semiconductor Capacitors, MOSFET: Principle of Operation, Charge Coupled Devices, Advanced MOS Devices.

Module IV (15 Hours)
Crystalline Solar Cells, Conversion Efficiency, p-n Junction Solar Cells, Spectral Response –Equivalent Circuit. Amorphous Silicon Solar Cells, Photo Detectors, PIN Diode Detectors, Electroluminescence of Electromagnetic Waves in Two Level Systems, LEDs, Semiconductor Lasers:Optical Gain, Integrated Optoelectronics.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Core Compulsory Readings

1. Sze S. M., Physics of Semiconductor Devices, John Wiley & Sons, 2015.
2. Donald A. Neamen, Semiconductor Physics and Devices by, Fourth Edition, 2019.
3. Michael Shur, Physics of Semiconductor Devices, Prentice Hall of India, 2004.
4. Goswami A., Thin Film Fundamentals, New Age Intemational Ltd. (1996)

Core Suggested Readings

1. S. S. Islam, Semiconductor Physics and Devices, Oxford University Press, (2010).
2. Karl Hess, Advanced Theory of Semiconductor Devices, Prentice Hall of India.
3. Jasprit Singh, Semiconductor Devices: An Introduction, McGraw Hill, (2001).

Teaching Learning Strategies

- Developing conceptual understanding

- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Explain the Bragg reflection of electron waves.
2. Discuss Hall effect and Magneto resistance.
3. Describe the principle of operation of MOSFET.

Semester - VIII

Research Methodology

Course Title	:	Research Methodology
Semester	:	08
Course Code	:	KU08DSCPHY401
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Basic research attitude, Language skills

Course Description:

- The basic aim of this course is to equip the students with necessary research tools for their Honours and/or future PhD works.
- This course helps researchers prepare their research plans, scope of the study, and to report the findings in an ethical manner.
- This course also provides an introduction to technical writing, complex graphics, and computer presentations with LaTeX

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Understand the importance of planning the research activities.	U, C
2	Develop efficiency in using research tools available.	An, E
3	Understand the ethical values in scientific research.	U, An
4	Learn intellectual honesty and scientific integrity.	A, An, C

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	-	-	-	2	2	2	3	2	-	3	2
CO2	-	-	-	2	2	2	3	2	-	3	2
CO3	-	-	-	2	2	2	3	2	-	3	2
CO4	-	-	-	2	2	2	3	2	-	3	2

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (15 hours): Scientific Research and Methodology
Meaning and characteristics of research; Types of Research and importance of research activities; Planning and designing research activity; Definition, characteristics, rules and principles of scientific method; Hypothesis- Definition, types of hypothesis, sources of hypothesis and testing of hypothesis; Experimental design; Interpretation and generalization of research findings.

Module II (15 hours): Scientific Writing
Importance and characteristics of scientific writing; Literature review, academic and general search engines, writing a literature review; Journals, scientific paper, review paper, short communication and rapid communication; Journal impact factor, citation index, h-index, g-index, hg- index, i10 index; Components of a scientific paper: title, abstract, key words, introduction,methodology, results and discussion, conclusion, references.

Module III (15 hours): Ethics of Research in Science
Philosophy of Ethics; Research as the pursuit of truth: Moral philosophy, nature of moral judgment and reactions; Factors Contributing to unethical conduct in research: Competition, Claiming priority, Ranking, Prestige associated with journal impact factor, Poor infrastructure; Ethics of using AI tools - adapting novel tools and judging the upper limit of the usage.

Module IV (15 hours): Scientific Conduct & Publication Ethics
Intellectual honesty & Research Integrity; Proper citation and acknowledgment; Author contribution types & Judging the Scientific impact; Scientific Misconduct: Fabrication, Falsification and Plagiarism (FFP); Examples of Fabrication and Falsification from literature; Plagiarism and Self-plagiarism; Plagiarism checking tools; Selective reporting: Cherry-picking data sets and misinterpretation; "Publish or Perish" culture: what to focus-quantity or quality of research publications; Evaluation of the integrity of a journal: Identifying predatory journals, Retraction Watch; The Role of UGC-CARE (Consortium for Academic Research and Ethics); The UGC-CARE Reference List of Quality Journals.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Core Compulsory Readings

1. K. Prathapan, "Research Methodology for Scientific Research" (Second Edition), iK International Publishers, New Delhi, (2023).
2. Academic Integrity and Research Quality, University Grants Commission, India (2021)
3. Good Academic Research Practices, University Grants Commission, India (2020)

Core Suggested Readings

1. C. George Thomas, "Research Methodology and Scientific Writing" Springer (2021).
2. Chaddah, P.; Ethics in Competitive Research: *Do not get scooped to not get plagiarized* (2018)
3. Scientific Values: Ethical Guidelines and Procedures, Indian Academy of Sciences (2018)

4. UGC-CARE. Reference List of Quality Journals. https://ugccare.unipune.ac.in/apps1/home.

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Describe the importance of planning the research activity.
2. Describe the main components of a scientific article.
3. Discuss the factors contributing to unethical conduct in research.

Advanced Quantum Mechanics

Course Title	:	Advanced Quantum Mechanics
Semester	:	08
Course Code	:	KU08DSCPHY402
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Quantum Mechanics, Classical Mechanics

Course Description:

- To give a detailed description of the quantum theory of scattering.
- Concepts of time dependent problems are introduced and the transition probability of the particles to be found in the final state due to time dependent perturbation or disturbance is calculated.
- This course also deals with the probability of transitions due to constant perturbation, transition to continuum and transition probability due to harmonic perturbation.
- The relativistic wave equation and the failure to consider Klein-Gordon wave equation as the true relativistic wave equation is discussed.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Explain Spin-Orbit interaction and the Born-Oppenheimer approximation in semi classical approach and the quantum theory of spectrum of atom and molecules.	R, U, An
2	Apply the time dependent perturbation theory to calculate the transition probability between different stationary states due to constant perturbation, harmonic perturbation, transition to continuum states etc.	U, An
3	Illustrate the theory of Scattering.	U, An
4	Describe the concept of negative energy states, the relativistic wave equation, and the concepts like Bose-Einstein statistics and Fermi-Dirac statistics.	U, A, An

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	1	-	2	-	-	-	-	-	-
CO2	3	3	1	-	2	-	-	-	-	-	-
CO3	3	3	1	-	2	-	-	-	-	-	-
CO4	3	3	1	-	2	-	-	-	-	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (12 hours)
Spin-Orbit Interaction, Fine Structure of Hydrogen Atom, Anomalous Zeeman Effect, The Hartree Equation for Atoms, Molecular Structure, Born-Oppenheimer Approximation, Molecular Orbital Method and Valence Bond Method, Hydrogen Molecule Ion and Hydrogen Molecule as Examples.

Module II (18 hours)
Time Dependent Perturbation Theory, Transition Probability, Constant Perturbation, Harmonic Perturbation, Interaction of an Atom with an Electromagnetic Field, Induced Emission and Absorption, Dipole Approximation, Born Approximation and Scattering Amplitude, Scattering: Scattering Cross Section and Scattering Amplitude, Low Energy Scattering by a Central Potential, Method of Partial Waves, Phase Shifts, Optical Theorem, Scattering by a Square Well Potential, The Born Approximation.

Module III (18 hours)
Relativistic Quantum Mechanics: Introduction, The First Order Wave Equations , Dirac Equations, Dirac Matrices, Solution of the Free Particle Dirac Equation, Spin of the Electron, Equation of Continuity, Non-relativistic Limit, Spin Orbit Coupling, Dirac Equation of Hydrogen Atom, Covariance of the Dirac Equation, Bilinear Covariants, The Hole Theory, The Weyl Equations for the Neutrino, The Second Order Wave Equations (The Klein-Gordon Equation, Wave Equation of the Photon, Charge Conjugation for Dirac and Klein-Gordon Equations), CPT Theorem.

Module IV (12 hours)
Quantization of Fields: Principles of Canonical Quantization of Fields, Lagrangian Density and Hamiltonian Density, Second Quantization of the Schrödinger Wave Field for Bosons and Fermions.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Core Compulsory Readings

1. V. K. Thankappan, Quantum Mechanics, Wiley Eastern.
2. Ghatak and Lokanathan, Quantum Mechanics, MacMillan
3. Bransden and Joachain, Introduction to Quantum Mechanics, ELBS.
4. Zettili, N, Quantum Mechanics: Concepts & Applications (2/e), Wiley (2009).

5. Griffiths, D J, Introduction to Quantum Mechanics, Pearson Education (2005).

Core Suggested Readings

1. Amit Goswami, Quantum Mechanics, Wm. C. Brown Publishers.

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Describe Spin orbit coupling.
2. Explain the reason why we need Dirac equation.

Condensed Matter Physics

Course Title	:	Condensed Matter Physics
Semester	:	08
Course Code	:	KU08DSCPHY403
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Introduction to Solid State Physics

Course Description:

- This course will introduce the advance concepts in band theory of solids.
- Explain theoretical concepts of semiconductors, dielectric, magnetic, and superconducting materials.
- Illustrate theories of heat capacity and superconductivity.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Explain the concept of band theory of solid and how to classify them.	R, U, E
2	Demonstrate the theoretical concepts of semiconductors, dielectric, magnetic, and superconducting materials.	U, An
3	Describe the concepts of different theories of specific heat capacity.	U, An
4	Explain the concepts of superconductivity theories and its application.	U, A, An

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	3	1	-	2	-	-	-	-	-	-
CO2	3	3	1	-	2	-	-	-	-	-	-
CO3	3	3	1	-	2	-	-	-	-	-	-
CO4	3	3	1	-	2	-	-	-	-	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (15 Hours)
Review of band theory, Construction of Fermi surfaces. Electron orbits, Hole orbits and Open orbits. Calculation of Energy Bands: Tight Binding Method for Energy Bands, Wigner-Seitz Method, Pseudopotential method. Experimental method: De Haas-van Alphen effect. Introduction to Plasmons, Polaritons, and Polarons, Optical Reflectance, Kramers-Kronig relations, Electronic interband transitions, Excitons: Frenkel excitons, Mott-Wannier excitons, Raman effect in crystals.

Module II (15 Hours)
Superconductivity: Occurrence of Superconductivity, Destruction of Superconductivity by Magnetic Fields, Meissner Effect, Thermodynamics of Superconductors, London Equation, Coherence Length, BCS Theory, Flux Quantization, Type I and Type II Superconductors. Superconductor tunneling: DC and AC Josephson effects. High-Temperature Superconductors.

Module III (15 Hours)
Dielectrics and Ferroelectric: General Concept, Dielectric constant and Polarizability, Ferroelectric crystals, Displacive transitions: Soft optical phonons, Landau theory of the phase transition, First and second order phase transitions, Ferroelectric domains, Piezoelectricity, and Ferroelasticity.

Module IV (15 Hours)
Magnetism: Diamagnetism and Paramagnetism, Classical and Quantum theories, Hund Rules, Van-Vleck and Pauli paramagnetism. Ferro magnetism and Antiferromagnetism, Curie-Weiss law, Heisenberg Model, Spin Wave, Magnetic Resonance.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Core Compulsory Readings

1. Charles Kittel, Introduction to Solid State Physics.
2. Ibach and Luth, Solid State Physics.
3. Marder, Condensed Matter Physics.
4. Ashcroft and Mermin., Solid State Physics.

Core Suggested Readings

1. A J Dekker, Solid State Physics

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Explain band structure of solids
2. Illustrate the formulation of nearly free electron model
3. Explain tight-binding approximation
4. Discuss the thermodynamics of superconductors.
5. Explain BCS theory.

KANNUR UNIVERSITY

Nuclear Physics

Course Title	:	Nuclear Physics
Semester	:	08
Course Code	:	KU08DSCPHY404
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Quantum Mechanics, Statistical Mechanics

Course Description:

- The main objective of the course is to provide a basic knowledge about nuclear models.
- To provide the concepts behind the nuclear forces.
- To explain scattering cross sections.
- To explain nuclear fission and fusion reactions and their characteristics.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Describe alpha, beta and gamma decay with corresponding selection rules.	U, E
2	Explain the basic knowledge of nuclear size, shape, binding energy. etc and also the characteristics of nuclear force.	U, An
3	Illustrate various nuclear models such as liquid drop model, shell model, collective model and Nilson model.	U, An
4	Describe the concept of negative energy states, the relativistic wave equation, and the concepts like Bose-Einstein statistics and Fermi-Dirac statistics. Describe the types of nuclear reactions and its applications.	U, A, An

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	3	1	-	2	-	-	-	-	-	-
CO2	3	3	1	-	2	-	-	-	-	-	-
CO3	3	3	1	-	2	-	-	-	-	-	-
CO4	3	3	1	-	2	-	-	-	-	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (18 Hours)
Nuclear size, Techniques for determining size, shape, mass and binding energy, semi empirical mass formula, Angular momentum and parity, nuclear electromagnetic moments, characteristics of nuclear force, the deuteron, Wave function, Spin and Parity, Magnetic dipole and electric quadrupole moment, Low energy Nucleon-nucleon scattering, Partial wave analysis of n-p scattering, determination of phase shift, Properties of nuclear force, Exchange force model, Yukawa hypothesis.

Module II (12 Hours)
Liquid drop model and drawbacks, Fermi gas model, Experimental evidence for magic numbers, shell model, shell model potentials, spin-orbit potential, magnetic dipole moments, electric quadrupole moments, valence nucleons, success of shell model, Even Z-even N nuclei; Collective structure.

Module III (18 Hours)
Theory of Alpha decay; Beta decay, Energy release in beta decay, Fermi theory of beta decay, Experimental tests of the Fermi theory, angular momentum and parity selection rules, parity violation in beta decay, Energetics of gamma decay, classical electromagnetic radiation, transition to quantum mechanics, angular momentum and parity selection rules, Internal conversion.

Module IV (12 Hours)
Types of reactions and conservation laws, Energetics of nuclear reactions, reaction cross sections, compound nucleus reactions, Nuclear fission, characteristics of fission, energy in fission, Nuclear fusion: basic fusion processes, characteristics of fusion, solar fusion.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Core Compulsory Readings

1. Harald Enge, Introduction to Nuclear Physics.
2. Kenneth S Krane, Introductory Nuclear Physics.
3. Roy R. K. and Nigam P. P., Nuclear Physics, Tata McGraw Hill.

Core Suggested Readings

1. J. S. Lilley, Nuclear Physics: Principles and Applications, John Wiley.

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Explain natural radioactivity.
2. Describe Yukawa's theory of nuclear reaction.
3. List the drawback of the liquid drop model of the nucleus.
4. Explain the basic working principle of ESR.
5. Distinguish nuclear Fission and Fusion.
6. Describe the characteristics of nuclear Fission.

KANNUR UNIVERSITY

Atomic & Molecular Physics

Course Title	:	Atomic & Molecular Physics
Semester	:	09
Course Code	:	KU09DSCPHY501
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Advanced Quantum Mechanics

Course Description:

- To give a detailed account of the spectra of hydrogen like atoms, spectra of alkali metals, and spectra of many electron systems.
- Explain the relativistic corrections to energy eigenvalues.
- To understand the theoretical formulation of many electron systems and coupling schemes for electronic angular momenta.
- To study light-matter interaction.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	To give a detailed account of the spectra of hydrogen like atoms, spectra of alkali metals, and spectra of many electron systems.	U, E
2	Explain the relativistic corrections to energy eigenvalues.	U, An
3	To establish the theoretical formulation of many electron systems and coupling schemes for electronic angular momenta.	U, An
4	Provides the knowledge of rotational and vibrational spectra of polyatomic molecules and to elucidate their structure through microwave and infrared spectroscopy.	U, A, An

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	3	1	-	2	-	-	-	-	-	-
CO2	3	3	1	-	2	-	-	-	-	-	-
CO3	3	3	1	-	2	-	-	-	-	-	-
CO4	3	3	1	-	2	-	-	-	-	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (15 Hours)
The concept of atom - Experimental and theoretical proofs for the existence of atoms; The structure of atoms - Basic concepts of integral and differential cross-sections; Scattering experiments - Thomson's & Rutherford's atomic models; Bohr's atom model; Frank - Hertz experiment; Schrodinger equation for One-electron system - Hydrogen atom; Quantum numbers and wave functions; Energy levels and spectra; The normal Zeeman effect; Relativistic correction of energy terms; Electron spin and Stern-Gerlach experiment; Spin-Orbit Coupling and Fine Structure; Anomalous Zeeman Effect; Hyperfine Structure; Lamb Shift.

Module II (15 Hours)
Atoms with more than one electron - The helium atom; Symmetry of the wave function; The Pauli principle; Helium spectrum; Building-up principle of the electron shell for larger atoms; Alkali atoms; Theoretical models for multi electron atoms - The model of Independent electrons, The Hartree method, Hartree-Fock method, Configuration interaction; Coupling schemes for electronic angular momenta; Electron configuration and atomic states.

Module III (15 Hours)
Interaction of Atoms with radiation - Electric dipole transition; Induced and spontaneous transitions; Einstein coefficients; Transition probabilities; Matrix elements; Transition probabilities for absorption and induced emission; Selection rules; Higher order multipole transitions & Magnetic dipole transitions; Spectral lines and line broadening mechanisms; Principle of lasing - Threshold Condition; Generation of population inversion; Optical resonators; The quality factor of resonators; Different Types of Lasers (Solid-state lasers, Semiconductor Lasers, Gas lasers).

Module IV (15 Hours)
Born-Oppenheimer approximation; The rigid rotor; Centrifugal Distortion; The influence of the electron motion; Vibrations of diatomic molecules; Simultaneous rotation and vibration; Spectra of diatomic molecules; Vibrational-Rotational transitions - P- and R-transitions; Electronic transitions; The Rotational structure of electronic transitions - The Fortrat-Diagrams; The Vibrational structure and the Franck–Condon principle; Rotation of polyatomic molecules; Principal moments of inertia; Rotation of symmetric top molecules; Vibrations of poly atomic molecules; Couplings between vibrations and rotations for poly atomic molecules; Rotational structure of vibrational bands; Raman spectroscopy - classical and quantum theory; Optical Cooling and Trapping of Atoms (Optional).

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Core Compulsory Readings

1. W Demtröder, Atoms Molecules and Photons (3/e), Springer (2018)

2. B. H. Brandsen and C. J. Joachain, Physics of atoms and molecules (2/e), Pearson Education (2008)

Core Suggested Readings

1. L D Landau and E M Lifshitz, Quantum Mechanics (Non-relativistic Theory) Course on Theoretical Physics-Vol 3 (3/e), Butterworth Heinemann (1977)

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Explain spin-orbit coupling.
2. Explain Raman effect
3. Distinguish between Zeeman effect and Stark Effect
4. Explain the spectra of Hydrogen like atoms
5. Discuss the theory of the vibrational spectrum of a molecule.
6. Explain rotational Raman spectra of rigid diatomic molecules.

Nanophotonics

Course Title	:	Nanophotonics
Semester	:	09
Course Code	:	KU09DSCPHY502
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Electromagnetic theory, Quantum physics

Course Description:

- This course will cover the interaction of light with nanoscale features on objects.
- The course will include mathematical foundations, including those of plasmonics and metamaterials, as well as a review of applications of nanophotonics and recently-published progress in the field.
- Ways to focus light and image objects beyond the diffraction limit will be presented.
- Explain stellar evolution.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Understand how scattering from small particles depends on particle size, shape, and composition.	R, U, An
2	To be familiar with the ways to numerically model light at the nanoscale.	U, An
3	Explain how both localized surface plasmons and surface plasmon polaritons can be used to concentrate light into nanoscale volumes.	U, An
4	Explain what optical metamaterials are and how they can be used to image objects with sub- diffraction-limit resolution.	U, A, An

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	1	-	2	2	2	-	-	-	-
CO2	3	3	1	-	2	2	2	-	-	-	-
CO3	3	3	1	-	2	2	2	-	-	-	-
CO4	3	3	1	-	2	2	2	-	-	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (15 hours)
What is nanophotonics?; Review of electromagnetism fundamentals; Finite difference time domain modeling method; Interaction of light with dipolar nanoparticles; Radiation reaction correction for particle polarizability; Lorentzian and Fano lineshapes; Relationship between classical and quantum mechanical dipoles.

Module II (15 hours)
Interaction of light with wavelength-scale particles; Coupled (discrete) dipole approximation modeling method; Mie scattering; Quadrupole approximations; Optical tweezers / optical manipulation of nanoparticles; Photonic crystals.

Module III (15 hours)
Interaction of light with plasmonic metals; Surface plasmon polaritons; Localized surface plasmons; Optical antennas; Purcell effect; Transmission through nanoscale apertures.

Module IV (15 hours)
Near-field scanning optical microscopy; Physical and mathematical foundations of the diffraction limit; Metamaterials, including double-negative media, hyperbolic metamaterials, transformation optics, and metasurfaces; Super-resolution microscopy, including multiphoton, STED, structured illumination, synthetic aperture, fluorescent localization (PALM/STORM), and confocal.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Core Compulsory Readings

1. L. Novotny and B. Hecht, Principles of Nano-Optics, 2nd edition, Cambridge University Press (2012)
2. C. F. Bohren and D. R. Huffman, Absorption and Scattering of Light by Small Particles, Wiley (1998).

Core Suggested Readings

1. J. D. Joannopoulos, S. G. Johnson, J. N. Winn, and R. D. Meade, Photonic Crystals: Molding the Flow of Light (2/e), Princeton University Press (2008).
2. J. Goodman, Fourier Optics, Roberts & Company (2005).
3. D. J. Griffiths, Introduction to Quantum Mechanics, Prentice Hall (1995).

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Describe the physical implications of diffraction limit of light.
2. Explain the difference between near field an far field in optical microscopy.
3. Explain Mie scattering and describe quadrapole approximations.

Quantum Field Theory

Course Title	:	Quantum Field Theory
Semester	:	09
Course Code	:	KU09DSCPHY503
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Advanced Quantum Mechanics

Course Description:

- Quantum Field Theory (QFT) is a fundamental theoretical framework that combines classical field theory, quantum mechanics and special relativity.
- This course provides a comprehensive introduction to the principles and techniques of QFT, which are essential for understanding the behaviour of fundamental particles and interactions in the universe.
- This course will be helpful for students who are interested in high-energy physics and/or condensed matter theory in future.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	To understand the quantization of fields and the significance of field operators.	U, E
2	To explore the concept of symmetries and conservation laws in field theory.	U, An
3	Introduces the relativistic effects in quantum mechanics and learns to deal large degrees of freedom.	U, An
4	Understand Quantum Field Theory applications in various branches of physics.	U, A, An

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	3	1	-	2	-	-	-	-	-	-
CO2	3	3	1	-	2	-	-	-	-	-	-
CO3	3	3	1	-	2	-	-	-	-	-	-
CO4	3	3	1	-	2	-	-	-	-	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (15 hours): Why quantum field theory
Principle of locality: Review of classical field theory; Action principle, Lagrangian and Hamiltonian; Symmetry and Noether's theorem; Implications of relativistic symmetry What is wrong with relativistic quantum mechanics; Special relativity plus quantum mechanics ; Continuum limit of discrete systems; Many condensed matter applications.

Module II (15 hours): Free scalar field theories & Interactions
Klein-Gordon filed as harmonic oscillator; Canonical quantization of a free scalar field; Particle interpretation; Propagators; Complex scalar fields. Path integrals for quantum mechanics; Path integral for quantum scalar fields; Perturbation theory:Feynman diagrams; Cross section and scattering matrix.

Module III (15 hours): Dirac Theory
Dirac equation and its Lorentz covariance; Canonical quantization; Spin and statistics;Discrete symmetries; Path integrals for Dirac fields.

Module IV (15 hours): Maxwell theory & Quantum electrodynamics
Maxwell theory; Gauge symmetry; Canonical quantization; Path integral quantization;Quantum electrodynamics; Feynman rules; Elementary processes; Compton and inverse Compton scatterings.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Core Compulsory Readings

1. Peskin, Michael E., and Daniel V. Schroeder. An Introduction to Quantum Field Theory. CRC Press (1995).
2. Steven Weinberg, The Quantum Theory of Fields, Volume 1: Foundations. Cambridge University Press (2005).
3. L. H. Ryder, Quantum filed theory, Cambridge University Press (1996).
4. Tom Lancaster, Stephen J. Blundell, Quantum Field Theory for the Gifted Amateur, Oxford Press (2015)

Core Suggested Readings

1. A. Lahiri & P.B. Pal, A First Book of Quantum Field Theory, Alpha Science International Ltd (2005)

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. State the Noether's theorem and show that a conserved current implies a conserved charge in the Lagrangian formulation of the classical field theorry.
2. Obtain the inhomogenous Maxwell's equation of motion from the Lagrangian density,

$$\mathscr{L} = -\frac{1}{4}F^{\mu\nu}F_{\mu\nu} - j^{\mu}A_{\nu}.$$

3. Using Wick theorem, evaluate

$$< 0|T\left(\phi^4(x)\phi^4(y)\right)|0 >$$

4. Draw Feynmann diagram for electron-positron annihilation into a muon-antimuon pair.
5. What is "Normal Ordering" in QFT ?

Particle Physics & Astrophysics

Course Title	:	Particle Physics & Astrophysics
Semester	:	09
Course Code	:	KU09DSCPHY504
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Quantum physics

Course Description:

- This course will explain nuclear interactions and discuss particle and energy exchange associated with strong and weak interaction.
- Describe the concept of resonance and the detection of the resonant particles
- Illustrate the conservation laws and intrinsic quantum numbers like baryon, strangeness, isospin, third components of isospin etc.
- Explain stellar evolution.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Explain strong nuclear force and describe the concept of resonance and the detection of the resonant particles using resonance production experiment and the resonance formation in experiment.	R, U, An
2	llustrate the conservation laws and intrinsic quantum numbers like baryon, strangeness, isospin, third components of isospin etc.	U, An
3	Describe the basic building block of matter and their discovery and explain the theory of the standard model of particle physics.	U, An
4	Explain the absolute and apparent magnitudes, the Harvard model of the classification of the stars, and the Hertzsprung – Russel Diagram for the representation of the stars.	U, A, An

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	1	-	2	-	-	-	-	-	-
CO2	3	3	1	-	2	-	-	-	-	-	-
CO3	3	3	1	-	2	-	-	-	-	-	-
CO4	3	3	1	-	2	-	-	-	-	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (18 hours)
Strong and Weak Nuclear Forces, Yukawa's Proposal, Pair Production, Properties and Modes of Decay of Pions and Muons, The Muon, The Real Pion, Isotopic Spin, Strange Particles, GellMann-Nishijima Formula, Extremely Short-Lived Particles, Resonances and Their Quantum Numbers with Special Reference to Pions, Nucleon Scattering, Conservation Laws, Intrinsic Quantum Numbers Associated with Elementary Particles, Theory of Weak Interaction, Parity Non-conservation, The TCP Theorem, Unification of Weak Electromagnetic Interaction, The Glashow-Weinberg-Salam Model.

Module II (15 hours)
Quark Model, The Sakata Model, The Eight-Fold way, Gell-Mann-Okubo and Coleman-Glashow Equations, Quarks and Quark Models, Different Types, The Confined Quarks, Experimental Evidence for the Existence of Quarks, Coloured Quarks, Charm, Truth and Beauty.

Module III (12 hours)
Absolute Magnitude and Distance Modulus, Colour Index of Stars, Luminosities of Stars, Stellar Parallax and Units of Stellar Distance, Celestial Sphere and Celestial Coordinate Systems, Harvard System of Classification of Stars, Spectroscopic Parallax, The Hertzsprung – Russell Diagram.

Module IV (15 hours)
Interstellar Dust and Gas, The Formation of Protostars, Pre-main Sequence: Evolution, Evolution of the Main Sequence, Late Stages of Degenerate Matter, The Chandrasekhar Limit, The Cooling of White Dwarfs, Neutron Stars, Pulsars, Quasars, Black Holes, Comets, Asteroids and Meteorites, The Formation of the Solar System.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Core Compulsory Readings

1. G. D. Coughlan and J. E. Dodd, The Ideas of Particle Physics (3/e), Cambridge University Press (1991).

2. Yuval Ne'eman and Yoram Kirsh, Particle Hunters (2/e), Cambridge University Press (1996).

3. Baidyanath Basu, An Introduction to Modern Astrophysics (2/e), Prentice Hall of India.

4. Bardley W. Carrol & Dale A. Ostile, An Introduction to Modern Astrophysics (2/e), Addison Wesley.

5. David Griffith, Introduction to Elementary Particle Physics, John Wiley & Sons.

Core Suggested Readings

1. M. P. Khanna, Introduction to Particle Physics, Prentice Hall of India.

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Describe strong and weak nuclear forces.
2. Explain quark models.
3. Describe H-R diagram.

General Theory of Relativity

Course Title	:	General Theory of Relativity
Semester	:	09
Course Code	:	KU09DSCPHY505
Course Type	:	DSC
Course Credits	:	4
Pre-requisites	:	Classical Mechanics, Mathematical Physics

Course Description:

- This course aims to develop a thorough understanding of the fundamental principles and concepts of General Theory of Relativity (GTR), including the geometric nature of gravitation.
- This course will help the students to master the mathematical tools and techniques used in GTR, such as tensor calculus and differential geometry.
- The experimental and observational evidence supporting GTR, such as the bending of light, perihelion precession of Mercury, and gravitational redshift will be discussed during this course.
- The derivation, solutions, and physical implications of Einstein's field equations will be explained.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Develop a deep understanding of the core principles and equations of GTR, including the concept of spacetime curvature.	U, E
2	Apply advanced mathematical techniques to derive and solve Einstein's field equations and analyze the properties of spacetime.	A, An
3	Critically evaluate the experimental and observational evidence for GTR and understand its significance in the broader context of physics.	An, E
4	Establish theoretical knowledge and problem-solving skills necessary for pursuing research in general relativity and related areas.	A, C

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	1	-	2	-	-	-	-	-	-
CO2	3	3	1	-	2	-	-	-	-	-	-
CO3	3	3	1	-	2	-	-	-	-	-	-
CO4	3	3	1	-	2	-	-	-	-	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (15 hours): Special Relativity & Tensor Calculus
The spacetime interval; the metric; Lorentz transformations ; spacetime diagrams;vectors; the tangent space; dual vectors; tensors; tensor products; the Levi-Civitatensor; index manipulation; electromagnetism; differential forms – Hodge duality;worldlines; energy-momentum tensor; perfect fluids; energy-momentum conservation.

Module II (15 hours): Riemannian Geometry
Maps charts and atlases; manifolds; differentiation of vectors; coordinate bases; thetensor transformation law;- partial derivatives are not tensors; canonical form of themetric; Riemann normal coordinates; tensor densities; volume forms and integration;covariant derivatives and connections; the Christoffel connection; parallel transport; geodesics; the Riemann curvature tensor; symmetries of the Riemann tensor; the Bianchi identity – Ricci and Einstein tensors ; Weyl tensor; Geodesic deviation equation.

Module III (15 hours): Einstein's equation & blackholes
Principle of Equivalence, Principle of General Covariance, gravitation as space time curvature; the Newtonian limit – physics in curved spacetime; Derivation of Einsteinfield equation, Schwarzchild blackhole solutions, Birkhoff's theorem;geodesics of Schwarzschild; Deflection of light by sun, perihelion precession; Symmetries and Killing vectors.

Module IV (15 hours): Cosmology
Homogeneity and isotropy; the Robertson-Walker metric; forms of energy-momentum;Friedmann equations; cosmological parameters; evolution of the scale factor; redshift; Hubble's law.

Module V*: Teacher Specific Module:
Area of content, transaction and evaluation are decided by the Faculty.

Core Compulsory Readings

1. J. B. Hartle, Gravity: An introduction to Einstein's General Relativity, Benjamin Cummings (2003).

2. Gravitation and Geometry: An Introduction to General Relativity, Sean Carroll.

3. Gravitation- Charles W. Misner, Kip S. Thorne, and John Archibald Wheeler (Princeton University Press 2017).

4. Weinberg S, Gravitation and Cosmology: Principles and Applications of The General Theory of Relativity, (Wiley, 2013)

5. Narlikar J V, ‘An Introduction to Relativity’, (Cambridge University Press, 2010).
6. General Relativity, Robert Wald.

Core Suggested Readings

1. General Relativity: An Introduction for Physicists M. P. Hobson , G. P. Efstathiou (cambridge Press 2005).

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. How gravity is different from other fundamental interactions in physics?
2. Explain the equivalence principle and principle of general covariance.
3. Prove that affine connection does not transform as a tensor .
4. Describe briefly the concept of parallel transport of a vector.

DEPARTMENT OF PHYSICS

FOUNDATION COURSES

Foundation Course List: Physics

Type	Course	Code	Credit	Semester
MDC	Sky and Beyond	KU01MDCPHY101	3	I
	Medical Physics: Bridging Science & Healthcare	KU02MDCPHY101	3	II
SEC	Scientific Writing	KU04SECPHY201	3	IV
	Scientific Computing	KU05SECPHY301	3	V
	Data Analysis & Visualization	KU06SECPHY301	3	VI

Multi Disciplinary Courses (MDCs)

Sky and Beyond

Course Title	:	Sky and Beyond
Semester	:	01
Course Code	:	KU01MDCPHY101
Course Type	:	MDC
Course Credits	:	3
Pre-requisites	:	High school level science

Course Description:

- This course provides a comprehensive overview of astronomy.
- Topics ranging from the formation of the solar system to the evolution of stars and galaxies are discussed.
- This course aims to provide a deeper understanding of the cosmos and its wonders, from the smallest planets to the largest galaxies.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	0	3	3	0	3	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Understanding the Foundations of Astronomy	U
2	Understand the constituents and formation of the solar system	U
3	Understand and explore Galaxies and Cosmology	U
4	Understanding Stellar Evolution	U

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	-	-	1	1	-	-	-	-	1
CO2	3	2	2	-	-	1	1	-	-	-	-	1
CO3	3	2	2	-	-	1	1	-	-	-	-	1
CO4	3	2	2	-	-	1	1	-	-	-	-	1

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (15 Hours)
Ancient Astronomy- Astronomy around the World, Methods of Astronomy and Astrophysics –The Scientific Method - Scope of Astronomy, Brightness Measurement, Distance Measurement-Measurement of Distances Within Solar System, Method of Parallax, The Method of Luminosity Distance.

Module II (12 Hours)
Astronomical Instruments - Optical Telescopes, Radio Telescopes, Space Telescopes - Hubble Space Telescope; Night Sky: Stars and Planets in Night Sky, Comets and Meteors, Familiarization with Common Constellations, Eclipses, Phases of the Moon.

Module III (18 Hours)
Formation of the Solar System; The Sun: Photosphere, Chromosphere, Solar Corona, Prominences, Sunspots and Solar Cycle, Solar Flares; The planets of the Solar System: Kuiper Belt, Oort Cloud; Classification of Stars: Spectral Types of Star, The Harvard Classification System, Hertzsprung—Russell Diagram; Milky Way Galaxy - Size, Shape and Structure of the Milky Way; Hubble Classification of Galaxies, Expanding Universe; Big Bang Models of the Universe, The Cosmic Microwave Background; Extrasolar Planetary Systems, Habitable Planets.

Core Compulsory Readings

1. K. D. Abhayankar, Astrophysics: Stars and Galaxies, University Press (2001).
2. Baidyanadh Basu, An Introduction to Astrophysics, PHI Learning Private Limited (2010).
3. Introduction to Astronomy and Cosmology, Ian Morison, Wiley (2008)

Core Suggested Readings

1. John Chambers and Jacqueline Mitton, From Dust to Life: The Origin and Evolution of our Solar System, , Princeton University Press (2017)
2. Weinberg, S. The First Three Minutes: A Modern View of The Origin Of The Universe, Basic Books, (1993)

Teaching Learning Strategies

- Interaction with learners
- Group presentation
- Individual presentation
- Assignment

Mode of Transactions

- Practical demonstration
- Black Board

- Power Point
- Smart class room

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

KANNUR UNIVERSITY

Medical Physics: Bridging Science & Healthcare

Course Title	:	Medical Physics: Bridging Science & Healthcare
Semester	:	02
Course Code	:	KU02MDCPHY101
Course Type	:	MDC
Course Credits	:	3
Pre-requisites	:	Nil

Course Description:

- This course aims to give a historical overview of medical physics.
- Holistic approach to the key milestones in the field will be followed.
- Latest developments and trends in the area of nuclear medicine, cardiology, and cancer treatment will be covered in the course.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	0	3	3	0	3	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Understand the historical development of the area	U
2	Learn the simplified picture of the latest developments in the area of medical physics	U
3	Understand the impact of physics in society through the latest technological developments in medical physics	An
4	Obtain a glimpse of the emerging technologies, including generative AI and robotic surgery, in the field	U, An

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	-	1	2	-	-	1	1	-	-	-	-	1
CO2	-	1	2	-	-	1	1	-	-	-	-	1
CO3	-	1	2	-	-	1	1	-	-	-	-	1
CO4	-	1	2	-	-	1	1	-	-	-	1	1

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (15 Hours)
Overview of Medical physics: Historical development - Discovery of X-rays by Wilhelm Roentgen (1895) as the starting point; Key milestones in the revolution of Medical Physics - Commercial X-ray computed tomography and Intensity-modulated radiotherapy for curing cancers; History of radio iodine therapy; History of Nuclear medicine imaging, History of positron emission tomography (PET) and electrical impedance tomography; Medical physics in cardiology; Electricity within the human body.

Module II (18 Hours)
Basic principles of X-ray imaging and computed tomography (CT) scans; How X-rays are generated; Ultrasound imaging: seeing with sound; What is Ultrasound? Images from echoes - ultra sound scanner; Optics to see around the corners: Bending of light rays; Optical fibers as light guides; Optical fibers in endoscopic applications; Different types of endoscopes; Lasers in surgery: What is a Laser beam? Power density of laser; Absorption and heating; Photocoagulation and photovaporization; Pulsed lasers; Laser surgery - selective absorption; Lasers in dermatology; Laser surgery on the eye; Radiation therapy: Killing tumors with radiation; Basics of magnetic resonance imaging (MRI), How MRI maps the body; MRI in breast cancer detection; Brain mapping and functional MRI; Overview of the safety concerns related to above techniques.

Module III (12 Hours)
Emerging Technologies: Robotic surgery and virtual reality in operation room; Photodynamic therapy; Optical coherence tomography (OCT); 4D ultrasound imaging; Artificial intelligence in diagnostic imaging; Proton therapy; Helium ion therapy.

Core Compulsory Readings

1. Suzanne Amador Kane & Boris A. Gelman, Introduction to Physics in Modern Medicine, CRC Press (2020)
2. Steve Webb, The contribution, history, impact and future of physics in medicine, Acta Oncologica, 2009, 48, 169-177; DOI: 10.1080/02841860802244158
3. Roger Muncaster, Medical Physics, Stanley Thornes Publishers (1996)

Core Suggested Readings

1. J E Robert, Meandering in Medical Physics - A personal account of hospital physics, CRC Press (1999)

Teaching Learning Strategies

- Interaction with learners
- Group presentation
- Individual presentation
- Assignment

Mode of Transactions

KANNUR UNIVERSITY

- Practical demonstration
- Black Board
- Power Point
- Smart class room

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Skill Enhancement Courses (SECs)

Scientific Writing

Course Title	:	Scientific Writing
Semester	:	4
Course Code	:	KU04SECPHY201
Course Type	:	SEC
Course Credits	:	3
Pre-requisites	:	Basic knowledge of text editing

Course Description:

- This course aims to introduce the scientific writing process.
- Introduce LaTeX as the writing tool.
- Basic data representation methods in LaTeXwill be introduced.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
2	1	3	2	2	4	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Learn the strategies for clear and concise scientific writing	U, C
2	Understand the elements and organization of a scientific article	U, C
3	Use LaTeX for document creation and formatting	C
4	Develop data representation skills and learn bibliography management	U, A

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	-	-	-	3	1	-	2	3	2	3	1	-
CO2	-	-	-	3	1	-	2	3	2	3	1	-
CO3	-	-	-	3	1	-	2	3	2	3	1	-
CO4	-	-	-	3	1	-	2	3	2	3	1	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (18 Hours)
Introduction to Scientific Writing: Importance and characteristics of scientific writing; Clarity and Conciseness: Strategies for clear and concise writing; Organization and Structure: Elements of a scientific paper/report (Abstract, Introduction, Methods, Results, Discussion, Conclusion, References); Research proposal writing - flowchart; Literature review, methodology and preliminary data presentation, statement of limitations and expected deliverables; Scientific ethics and misconducts reported in the scientific world; How to identify fabricated data sets.

Module II (12 Hours)
LaTeX Introduction: Installing LaTeX and understanding its components; Basic document creation and formatting in LaTeX; Mathematics and Equations in LaTeX; Cross-referencing and labels in LaTeX documents.

Module III (15 Hours)
Figures and Tables in LaTeX: Including graphics and tables in scientific documents; Citations and Bibliography Management: Introduction to BibTeX for handling references; Writing Scientific Presentations:Creating slides using LaTeX beamer class.

Core Compulsory Readings

1. Michael Alley, The Craft of Scientific Writing
2. Angelika H. Hofmann, Scientific Writing and Communication: Papers, Proposals, and Presentation

Core Suggested Readings

1. Leslie Lamport, LaTeX: A Document Preparation System
2. G M Whitesides, Writing a paper, Adv. Mater, 16, 15 (2004)

Teaching Learning Strategies

- Interaction with learners
- Group presentation
- Individual presentation
- Assignment

Mode of Transactions

- Practical demonstration
- Black Board
- Power Point
- Smart class room

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Describe the main elements of a scientific article.
2. State the importance of systematic data analysis in a research project.

Scientific Computing

Course Title	:	Scientific Computing
Semester	:	5
Course Code	:	KU05SECPHY301
Course Type	:	SEC
Course Credits	:	3
Pre-requisites	:	Basic knowledge of computation

Course Description:

- This course aims to introduce the basics of scientific computing.
- Introduce numerical methods to solve problems.
- Basic programming methods will be introduced.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
2	1	3	2	2	4	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Learn the strategies of numerical methods	U, C
2	Understand the elements of programming in C	U, C
3	Use numerical methods to solve problems in physics/chemistry	C
4	Acquire good programming skill and develop good data representation strategies	U, A

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	1	2	2	-	2	2	-	-	-	-	-	-
CO2	1	2	2	-	2	2	-	-	-	-	-	-
CO3	1	2	2	-	2	2	-	-	-	-	-	-
CO4	1	2	2	-	2	2	-	-	-	-	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (15 Hours): Numerical Methods
Introduction to numerical methods, Distinguishing analytical and numerical methods - Curve fitting: Principle of least squares, Least square fitting of a straight line - Interpolation: Finite difference operator, Newton's forward difference interpolation formula, difference table. Solution of differential equations: Euler's method, Runge - Kutta method (Second order) - Taylor's Series expansion of sin x and cos x, First and second derivative by Numerical differentiation - Solution of algebraic equations: Bisection method-Newton-Raphson method, Numerical integration by Trapezoidal and Simpson's (1/3) method.

Module II (15 Hours): Programming in C
Introduction to C-Language, algorithm, flowchart, Constants and variables-data types-variable declarations - assignments and expressions - input and output statements - Arrays - conditional statements - control flow statements-loops, Structures, Pointers, writing files into a file, extracting data from files, C- libraries.

Module III (30 Hours): Practical
1. Write and execute c programmes for straight line fitting using Least square fitting.
2. Write and execute c programmes for interpolation for a given data set.
3. Write and execute c programmes for extrapolation for a given data set.
4. Write and execute a program for finding solutions for differential equations using Euler's method.
5. Write and execute a program for finding solutions for differential equations using Runge - Kutta method.
6. Write and execute c programmes to find the numerical solution of equations by Bisection method.
7. Write and execute c programmes to find the numerical solution of equations by Newton-Raphson method.
8. Write and execute c programmes to do Numerical differentiation using difference table
9. Write and execute c programmes to do Numerical integration.
10. Write and execute c programmes to check convergence or divergence of power series.
11. Write and execute c programmes for simulating a freely falling body.
12. Write and execute c programmes for simulation of projectile motion.

Core Compulsory Readings

1. William R Gibbs, Computation in modern physics, World Scientific (1994)
2. S. S. Shastry, Introductory methods of numerical analysis (5/e), Prentice Hall of India

Core Suggested Readings

1. V. K. Mittal, R. C. Verma and S. C. Gupta, Computational Physics, Ane Books

Teaching Learning Strategies

- Interaction with learners
- Group presentation
- Individual presentation

- Assignment

Mode of Transactions

- Practical demonstration
- Black Board
- Power Point
- Smart class room

<table>
<tr><th colspan="3">Assessment Rubrics</th><th>Total</th></tr>
<tr><td>End Semester Evaluation</td><td>External Test</td><td>50</td><td>50</td></tr>
<tr><td rowspan="4">Continuous Evaluation</td><td>Internal Exams</td><td>20</td><td rowspan="4">50</td></tr>
<tr><td>Assignments</td><td>10</td></tr>
<tr><td>Seminar</td><td>10</td></tr>
<tr><td>Viva</td><td>10</td></tr>
</table>

Sample Questions to test Outcomes

1. Explain least square fitting.
2. Discuss control flow statement in a programming language.

Data Analysis & Visualization

Course Title	:	Data Analysis & Visualization
Semester	:	6
Course Code	:	KU06SECPHY301
Course Type	:	SEC
Course Credits	:	3
Pre-requisites	:	Scientific computing

Course Description:

- This course aims to introduce the basics of data analysis.
- Introduce various data visualization methods.
- Basic programming methods will be introduced.

Credits			Teaching Hours/Week			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
2	1	3	2	2	4	50	50	100

*L/T = Lecture/Tutorials; P/I = Practical/Internship; CE = Continuous Evaluation; ESE = End Semester Evaluation.

Course Outcome:

CO No.	Expected Outcome	Learning Domains
1	Learn the strategies of data analysis	U, C
2	Understand the elements of programming in C/python	U, C
3	Use numerical methods to analyze experimental data	C
4	Acquire good programming skill and develop good data representation strategies	U, A

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	1	2	2	-	2	2	-	-	-	-	-	-
CO2	1	2	2	-	2	2	-	-	-	-	-	-
CO3	1	2	2	-	2	2	-	-	-	-	-	-
CO4	1	2	2	-	2	2	-	-	-	-	-	-

*Correlation Level: Substantial/High = 3, Moderate/Medium = 2, Low = 1, Nil = -

Course Contents:

Module I (15 Hours)
Data Analysis: Fast-Fourier transform, Spline interpolation of data, chi-square distribution and numerical error analysis. Theory of distribution functions and generating trial data using normal,log-normal and exponential functions.

Module II (15 Hours)
Data Visualization:Multiple plots-Polar plot-Pie charts, Plotting mathematical functions, Power series, Fourier series, 2D plots, 3D plot-surface and line plots.

Module III (30 Hours): Practical
1. Straight line fitting using Least square fitting.
2. Interpolation for a given data set.
3. Extrapolation for a given data set.
4. Finding solutions for differential equations using Euler's method.

Core Compulsory Readings

1. Python for Education - B P Ajithkumar

Core Suggested Readings

1. V. K. Mittal, R. C. Verma and S. C. Gupta, Computational Physics, Ane Books
2. S. S. Shastry, Introductory methods of numerical analysis (5/e), Prentice Hall of India

Teaching Learning Strategies

- Interaction with learners
- Group presentation
- Individual presentation
- Assignment

Mode of Transactions

- Practical demonstration
- Black Board
- Power Point
- Smart class room

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

DEPARTMENT OF CHEMISTRY

SYLLABUS

KANNUR UNIVERSITY

FIVE YEAR INTEGRATED MASTERS PROGRAMME (FYIMP)

SYLLABUS

MAJOR DISCIPLINE

CHEMISTRY

SCHOOL OF CHEMICAL SCIENCES

SWAMI ANANDATHEERTHA CAMPUS

PAYYANUR

JULY 2024

CONTENTS

BOARD OF STUDIES

NO	NAME	DESIGNATION
1	Prof.(Dr.) Sudheesh S	Professor and HoD Department of Chemistry Kannur University
2	Prof.(Dr.) Haridas K. R	Professor Department of Chemistry Kannur University
3	Dr. Baiju K V	Associate Professor Department of Chemistry Kannur University
4	Dr. Biju A R	Associate Professor Department of Chemistry Kannur University
5	Dr. Shima P. D	Assistant Professor Department of Chemistry Kannur University
6	Dr. Anjali Devi J S	Assistant Professor Department of Chemistry Kannur University
7	Dr. Anjali Paravannoor	Assistant Professor (On Contract) Department of Chemistry Kannur University
8	Dr. Nijisha P	Assistant Professor (On Contract) Department of Chemistry Kannur University
9	Dr. Mili C. N	Assistant Professor (On Contract) Department of Chemistry Kannur University

Programme Outcomes (POs)

PO1	**Critical Thinking**: Take informed actions after identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational, and personal) from different perspectives.
PO2	**Problem Solving**: Identify, formulate, conduct investigations, and find solutions to problems based on in-depth knowledge of relevant domains.
PO3	**Communication**: Speak, read, write and listen clearly in person and through electronic media in English/Language of the discipline, and make meaning of the world by connecting people, ideas, books, media and technology.
PO4	**Responsible Citizenship**: Demonstrate empathetic social concern, and the ability to act with an informed awareness of issues.
PO5	**Ethics**: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them.
PO6	**Self-directed and Life-long Learning**: Acquire the ability to engage in independent and life-long learning in the broadest context of socio- technological changes.
PO7	**Environmental Sustainability and Global Perspective**: Develop an understanding of global standards to foster a legal environment. Learn and practice to critically analyse the legal issues from local, national and international concerns.
PO8	**Network and Collaborative skills**: To be collaborate and network with scholars in an educational institution, professional organizations, research organizations and individuals in India and abroad

Programme Specific Outcomes (PSOs)

PSO1	Use theoretical concepts and principles in physical sciences (Physics/Chemistry) with specific emphasis on advanced material science to cater to the real-world problems.
PSO2	Apply mathematical techniques to solve and interpret the results of various physical/chemical systems.
PSO3	Illustrate the methodology required for the execution of physical/chemical experiments and analyze the experimental results with the corresponding interpretations

PSO4	Develop communication skills to explain the basic concepts to both specialized and nonspecialized audiences.

COURSE CATEGORY CODES

SL.NO	NAME OF COURSE	CODES
1	Ability Enhancement Course	AEC
2	Multi-Disciplinary Course	MDC
3	Discipline Specific Core	DSC
4	Discipline Specific Elective	DSE
5	Value Added Courses	VAC
6	Skill Enhancement Course	SEC

KANNUR UNIVERSITY

KANNUR UNIVERSITY SCHOOL OF CHEMICAL SCIENCES Swami Anandatheertha Campus, Payyanur Five Year Integrated Masters Programme (FYIMP) Curriculum Framework (Effective from 2024 admissions)					
Semester	**Course Code**	**Course Name**	**Credits**		
			L/T	**P**	**Total**
SEM-1	KU01DSCCHE101	Fundamentals of Chemistry-I	4	0	4
	DSC-B1		4		4
	DSC-C1		4		4
	AEC-1		3		3
	AEC-2		3		3
	MDC-1		3		3
		Maximum Credit in Semester I = 21			
SEM-II	KU02DSCCHE102	Fundamentals of Chemistry-II	4	0	4
	KU02DSCCHE103	Coordination Chemistry-I	4	0	4
	DSC-B2/C2		4	0	4
	DSC-B3/C3		4	0	4
	AEC-3		3	0	3
	MDC-2		3	0	3
		Maximum Credit in Semester II = 22			
SEM-III	KU03DSCCHE201	Physical Chemistry-I	4	0	4
	KU03DSCCHE202	Introduction to Organic Chemistry	4	0	4
	KU03DSCCHE203	Coordination Chemistry-II	4		4
	KU03DSCCHE204	Inorganic Chemistry Practical-I	0	4	4
	MDC-3	Kerala Studies	3	0	3
	VAC-1		3	0	3
		Maximum Credit in Semester III= 22			
SEM-IV	KU04DSCCHE205	Conceptual Organic Chemistry	4	0	4

	KU04DSCCHE206	Physical Chemistry-II	4	0	4
	KU04DSCCHE207	Coordination Chemistry-III	4	0	4
	KU04DSCCHE208	Physical Chemistry Practical-I	0	4	4
	SEC-1		3	0	3
	VAC-2		3	0	3
		Maximum Credit in Semester IV = 22			
SEM-V	KU05DSCCHE301	Organic Chemistry Practical-I	0	4	4
	KU05DSCCHE302	Reactive Organic Chemistry	4	0	4
	KU05DSCCHE303	Physical Chemistry III	4	0	4
	KU05DSCCHE304	Inorganic Practical-II	0	4	4
	KU05DSECHE305 KU05DSECHE306	(1) Polymer Chemistry (2) Medicinal Chemistry	4	0	4
	SEC-2		3	0	3
		Maximum Credit in Semester V = 23			
SEM-VI	KU06DSCCHE307	Organometallic Chemistry	4	0	4
	KU06DSCCHE308	Theoretical Chemistry-I	4	0	4
	KU06DSCCHE309	Physical Chemistry Practical-II	0	4	4
	KU06DSECHE310 KU06DSECHE311	(1) Environmental Chemistry (2) Nano medicine and Drug Delivery	4	0	4
	SEC-3		3	0	3
	INTERNSHIP		0	4	4
		Maximum Credit in Semester VI = 23			
Students exiting after 3 years- awarded UG degree with Major A					
SEM-VII	KU07DSCCHE401	Spectroscopy-I	4	0	4
	KU07DSCCHE402	Progressive Organic Chemistry	4	0	4
	KU07DSECHE403	Organic Chemistry Practical II	0	4	4
	KU07DSECHE404 KU07DSECHE405 **OR**B4/C4	(1) Super Capacitors for electrochemical energy storage. (2) Supramolecular Chemistry	4	0	4
	KU07DSECHE406	(1) Food Chemistry	4	0	4

	KU07DSECHE407 **OR**B5/C5	(2) Nuclear Chemistry			
	MOOC1/ONLINE		4	0	4
		Maximum Credit in Semester VII = 24			
SEM-VIII	KU08DSCCHE408	Group Theory	0	4	4
	KU08DSECHE409 KU08DSECHE410 KU08DSECHE411	(1) Forensic Chemistry and Toxicology (2) Catalysis, Kinetics and Solutions (3) Instrumentation Techniques	4	0	4
	MOOC/ONLINE2		4	0	4
	PROJECT	Project (12 credits)	12	0	12
	KU08DSECHE412	(1) Computational Chemistry	4	0	4
	KU08DSECHE413	(2) Ceramics and Composite Materials	4	0	4
	KU08DSECHE414 KU08DSECHE415	(3) Analytical Chemistry (4) Advanced Electrochemistry	4	0	4
		Maximum Credit in Semester VIII = 20			
SEM-IX	KU09DSCCHE416	Spectroscopy-II	4	0	4
	KU09DSCCHE417	Theoretical Chemistry-II	4	0	4
	KU09DSCCHE418	Statistical Mechanics and Nonequilibrium Thermodynamics	4	0	4
	KU09DSCCHE419	Advanced Organic Laboratory	4	0	4
	KU09DSCCHE420	Bioinorganic Chemistry	4	0	4
		Maximum Credit in Semester IX= 20			
SEM-X		RESEARCH			20
		Maximum Credit in Semester X = 20			

LIST OF FOUNDATION COURSES

LIST OF MDC COURSES

			L/T	**P**	**Total**
SEM-1	KU01MDCCHE101	Understanding the Nanoworld	3	0	3
SEM-II	KU02MDCCHE102	Basic Biochemistry an Introduction to Biomolecules	3	0	3
SEM III	KU03MDCCHE201	Biopolymers	3	0	3

LIST OF VALUE-ADDED COURSES					
SEM III	KU03VACCHE202	Water Quality Analysis	3	0	3
SEM-IV	KU04VACCHE203	Food Adulteration	3	0	3
LIST OF SKILL ENGHANCEMENT COURSE					
SEM IV	KU04SECCHE204	Chromatographic Techniques	3	0	3
SEM V	KU05SECCHE301	Safety Laboratory Practices	3	0	3
SEM VI	KU06SECCHE302	Advanced Techniques for Characterization of Materials	3	0	3

KANNUR UNIVERSITY

SEMESTER I

DISCIPLINE SPECIFIC CORE (DSC)

FUNDAMENTALS OF CHEMISTRY -I

Course Title	**:**	**Fundamentals of Chemistry- I**
Course Code	**:**	**KU01DSCCHE101**
Course Type	**:**	**DSC**
Course Credits	**:**	**4**
Pre-requisites	**:**	**Atomic models, basic organic concepts, elements**

Course Objectives:

- To study the various atom models, structure andunderstand the important features of the quantum mechanical model of the atom.
- To study the periodic properties of elements.
- To explain the basic concepts oforganic chemistry
- To predict the geometry of simple moleculeand explain the different types of hybridisation and draw shapes of simple covalent molecules.

Credit			Teaching Hours			Assessment		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
4	0	4	4	0	4	50	50	100

Course outcomes:

C01	Applybohr atomic model toexplain atomic spectrum,electronic configurations, atomic behavior, and characteristics.
C02	Describe the significance of organic chemistry, catenation ,hybridisation and electron displacement patterns in organic molecules.
C03	Apply the bonding concepts to molecules.
C04	Utilize mechanisms to illustrate and solve simple chemical reactions involving reactive intermediates.
C05	Analyse periodic trends, periodic properties,and the relationship between electronic configuration and the chemical reactivity of elements, including the formation of chemical bonds.

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	2	3	2	3	3	2	2	3	1	1
CO2	3	3	2	3	2	3	3	2	2	3	1	1
CO3	3	3	2	3	3	2	3	2	2	3	1	1
CO4	3	3	3	2	3	3	3	2	2	3	1	1
CO5	3	3	3	2	3	3	3	2	2	3	1	1

Module I: **15 hours**

Atomic Structure:1.1Bohr model of hydrogen atom,1.2 atomic spectrum of hydrogen atom, 1.3 Bohr's equation for the energy of electron in hydrogen atom, 1.4 explanation using Bohr atom model, 1.5 limitations of Bohr atom model,1.6 photoelectric effect, 1.7 dual nature of matter, 1.8 de Broglie equation, 1.9 Heisenberg's Uncertainty Principle and its significance,1.10 Concept of orbit and orbital, 1.11 Quantum numbers and their significance,1.12 Pauli's Exclusion Principle, 1.13 Hund's rule of maximum multiplicity,1.14 Aufbau principle-electronic configuration of atoms (Up to atomic number 30), 1.15 Nodal planes in atomic orbitals, 1.16 Zeeman effect, 1.17 shapes of s, p and d orbitals- energy level diagram of a multielectron atom,1.18 Schrodinger wave equation (derivation not expected),1.19 wave functions, 1.20 significance of Ψ (psi) and Ψ^2.

Module II: **15 hours**

Chemical Bonding: 2.1Ionic bond – nature of ionic bond, 2.2 properties of ionic compounds, radius ratio and coordination number, 2.3 factors favouring the formation of ionic compounds. 2.4 Covalent bond,2.5 hybridisation and shapes of simple molecules (BeF_2, PCI_3, SF_6, CH_4, Ethane, ethene and ethyne), 2.6 VSEPR theory- shapes of molecules and ions (NH_3, XeF_6, CIF_3, NH_4 +, H_3O^+), 2.7Lattice energy, 2.8 Born-Lande equation- lattice enthalpy, 2.9 Born-Haber cycle and itsapplications, 2.10 solvation enthalpy and solubility of ionic compounds, 2.11 molecular orbital energy diagram of homo andhetero diatomic molecules (N_2, O_2, CO and NO), 2.12 bond strength and bond energy, 2.13 Polarisation ofcovalent bond, 2.14 polarising power and polarizability of ions, 2.15 Fajan's rule, 2.16 Dipole moment– percentage ionic character from dipole moment, 2.17Metallic bonding – band theory, 2.18 Weak chemical forces – hydrogen bond, inter and intramolecular hydrogen bonds, 2.19 effects of hydrogen bonding, 2.20 van der Waals forces.

Module III: **15 hours**

Basic concepts of organic chemistry: 3.1 Symbols, formulae, 3.2 Chemical equations, classification (periodic classification of elements, classification of organic compounds into homologous series),3.3 qualitative and quantitative analysis, 3.4 IUPAC nomenclature of organic compounds, 3.5 Carbon: catenation and hybridizations (with examples Ethane, ethene, ethyne) 3.6 Polarity of bonds (basic concepts): Homolysis and heterolysis with examples,3.7 Electron displacement effects,3.8 Inductive effect: Influence of inductive effect in the acidity of carboxylic acids,3.9 Resonance effect (delocalization, contributing structures, and stability) 3.10 Hyperconjugation Reactive intermediates: Formation, structure and stability of carbocations, carbanions, and free radicals, 3.11Synthetic methodologies, condensation, addition, examples, 3.12 Separation and purification techniques – Filtration, Crystallization and precipitation , 3.14 Fractional distillation, 3.15 Solvent extraction.

Module IV: **15 hours**

Chemistry of elements:4.1 Modern periodic law – Long form periodic table, 4.2 Classification of elements as s,p,d& f block, 4.3 Classification- Metal, Non-metals & metalloids, 4.4 Diagonal relationship and anomalous behaviour, 4.5 periodicity in properties: Atomic and ionic radii - ionization enthalpy - electron affinity (electron gain enthalpy) – electronegativity, 4.6 Electronegativity scales: Pauling Scale,4.7 Effective nuclear charge, 4.8 Slater rule and its applications, 4.9 Valency and oxidation state with examples, 4.10Nomenclature of elements with atomic number greater than 100.

References

1. B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, Vikas Publishing Co. Jalandhar, 2013.
2. J. D. Lee, Concise Inorganic Chemistry, 5th Edition, Chapman & Hall, 2009.
3. P. W. Atkins and J. de Paula, Physical Chemistry, 11th Edition, Oxford University Press, 2018.
4. Morrison, R.T., Boyd, R.N. & Bhattacharjee, S.K. Organic Chemistry, 7th ed., Dorling Kindersley (India) Pvt. Ltd (Pearson Education), 2011.
5. Graham Solomon, T.W., Fryhle, C.B. & Snyder, S.A. Organic Chemistry, John Wiley & Sons, 2014.

6. Bahl, A. &Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.
7. F. A. Cotton, G. Wilkinson and P. L. Gaus, Basic Inorganic Chemistry, 3rd edn., John Wiley, 2007.
8. D. F. Shriver and P. W. Atkins, Inorganic Chemistry, 4th edn., Oxford University Press, 2006.

Teaching Learning Strategies

- Provide updated Lecture Sessions
- Promote Interactive Sessions including discussions and demonstrations.
- Provide experiments to engage students actively and visual aids like presentations, videos, and models to enhance understanding.
- Encourage students to ask questions during or after the lectures

MODE OF TRANSACTION

• Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes.

1. Explain the Bohr model of the hydrogen atom
2. Predict the hybridization and shapes of simple molecules (BeF_2, PCl_3, SF_6)
3. Distinguish between homolysis and heterolysis with examples
4. Describe the terms ionization enthalpy, electron affinity, and electronegativity.

SEMESTER II

DISCIPLINE SPECIFIC CORE (DSC)

FUNDAMENTALS OF CHEMISTRY II

Course Title	:	**Fundamentals of Chemistry- II**
Course Code	:	**KU02DSCCHE103**
Course Type	:	**DSC**
Course Credits	:	**4**
Pre-requisites	:	**Different forms of matter, bonds, basics of analytical chemistry**

Course Objectives:

- To explore the various forms substances can take -solid, liquid and gasand emphasize their properties and transitions based on temperature and pressure changes.
- To examine the fundamental reactions involving carbon compounds, focusing on key mechanisms and types of reactions
- To explain the basic concepts in Analytical Chemistry and to introduce techniques and principles essential for chemical analysis.
- To understand the significance of chemistry in everyday life

Credit			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

Course outcomes:

C01	Describe the fundamental principles governing the behaviour of different states of matter.
C02	Predict and classify various types of organic reactions based on their mechanisms.
C03	Compare and distinguish the properties of solids, liquids, and gases.
C04	Apply the basic principles of analytical chemistry in preparation of standard solutions, titrations and in the data analysis.
C05	Analyse the importance of chemistry in everyday life

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	2	3	2	3	3	2	2	3	1	1
CO2	3	3	2	3	2	3	3	2	2	3	1	1
CO3	3	3	2	2	3	2	2	2	2	3	1	1
CO4	3	3	3	2	3	3	2	2	2	3	1	1
CO5	3	3	3	2	3	3	3	2	2	3	1	2

Module I: States of matter 15 hours

1.1Matter and its different states, 1.2 Intermolecular Forces: dipole-dipole interaction, Dipole-induced dipole interaction and induced dipole-induced dipole interaction, 1.3 Ion-dipole interaction,1.4 Hydrogen bonding: intra and intermolecular hydrogen bonds- effect on physical properties, 1.5 Gaseous state,1.6 postulates of Kinetic theory, 1.7 Ideal and real gas behavior,1.8 compressibility factor deviation from ideal behavior, 1.9 van der Waals equation (No derivation), 1.10Liquid state,1.11Properties of liquids: Vapour pressure, boiling point, Surface tension, Viscosity, 1.12 Solid state,1.13Types of Solids: Crystalline and amorphous solids,1.14 Ionic solids, 1.15 Unit cell, 1.16 Crystal systems, 1.17 Bravais lattices.

Module II: Introduction to organic reactions 15 hours

2.1 Reactions of alcohols, 2.2 aldehydes, 2.3 ketones, 2.4 carboxylic acids, 2.5 nitro compounds,2. 6 Representation of organic molecules: Projection formula (Fischer, Sawhorse, wedge, Newman), 2.7Types of reagents: Electrophiles andnucleophiles,2.8 Addition reactions: Markovnikov's addition, 2.9 peroxide effect, 2.10 Elimination reactions: E1 and E2 mechanism, 2.11 Substitution reactions (SN1, SN2 reactions of alkyl halides only),2.12Polymerization reactions,2.13 Addition Polymerization (polyethylene, PVC) and Condensation polymerization (Nylon 6,6, polyester).

Module III: Analytical methodologies and Data analysis 15 hours

3.1 Fundamental concepts -mole, molarity, molality, ppm, 3.2primary standard – secondary standard, 3.3 quantitative dilution – problems, 3.4Acid-basetitrations,3.5 titration curve, 3.6 pH indicators, 3.7 Redox titrations:titration curve- titrations involving MnO_4, - and $Cr_2O_7^{2-}$, redox indicators,3.8 Complexometric titrations- EDTA titrations, titration curves, indicators, 3.9 gravimetricanalysis,3.10 Units, 3.11 significant digits- rounding, 3.12 scientific and prefix notation, 3.13 graphing of data, 3.14 Precision andaccuracy, 3.15 types of errors 3.16 Ways of expressing precision,3.17 Ways to reduce systematic errors,3.18 reporting analytical data, 3.19 Statistical treatment of analytical data,3.20 population and samples,3.21 Mean and standard deviation 3.22 distribution of random errors,3.23 confidence limits,3.24 tests of significance.

Module IV: Chemistry in daily Life 15 hours

4.1 Chemicals in medicines – Classification of drugs- analgesics, tranquilizers, antiseptics, disinfectants, antimicrobials, antifertility drugs, antibiotics, antacids, antihistamines (examples each),4.2 Psychotropic drugs - Tranquilizers, Antidepressants, and Stimulants with examples (Structures Not needed). 4.3 Drug addiction and abuse, Prevention and treatment,4.4 Chemicals in food- preservatives, 4.5 artificial sweetening agents, 4.6 elementary idea of antioxidants,4.7 cleansing agents- soaps and detergents (examples each),cleansing action,4.8 paints- varnishes-textiles-dyes- fuels etc(one example each), 4.9Fertilizers – Introduction. 4.10 Types of fertilizers - Natural, Synthetic, 4.11 NPK fertilizers,4.12 Excessive use of fertilizers and its impact on the environment, 4.13 Bio-fertilizers and Organic Manures. 4.14 Pesticides – Introduction, 4.15 Classification (Brief idea only), 4.16 Insecticides,4.17 Fungicides, 4.18 Herbicides (Structures not needed),4.19 Excessive use of pesticides,4.20 Environmental hazards, 4.21Biopesticides

References

1 .D.A. Skoog, D.M. West, F.J. Holler and S.R. Crouch, Fundamentals of Analytical Chemistry, 8th Edition, Brooks/Cole, Thomson Learning, Inc., USA, 2004.

2. Vogels Textbook of Quantitative Chemical Analysis, 6th Edn., Pearson Education Ltd.

3. Morrison, R.T., Boyd, R.N. & Bhattacharjee, S.K. Organic Chemistry, 7th ed., Dorling Kindersley (India) Pvt. Ltd (Pearson Education), 2011.

4. Graham Solomon, T.W., Fryhle, C.B. & Snyder, S.A. Organic Chemistry, John Wiley & Sons, 2014.

5. Bahl, A. &Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.

6. Puri, Sharma and Pathania, "Principles of Physical Chemistry", 47th Edition, Vishal Publishing Co, 2020.

7. K. L. Kapoor, "A Textbook of Physical chemistry", Volume 1, Macmillan India Ltd

8. Tisdale, S.L., Nelson, W.L. and Beaton, J. D. Soil Fertility and Fertilizers, Macmillian Publishing Company, New York, 1990.
9. Buchel, K.H. Chemistry of Pesticides, John Wiley & Sons, New York, 1983. .
10. Gowariker V.R., Viswanathan N.V. and Jayader Sreedhar, Polymer Science, Wiley Eastern Ltd., 1987.
11. H. Singh, V.K Kapoor, Organic Pharmaceutical Chemistry, Vallab Prakasan, 2011.
12. T Coultate, Food: The Chemistry of Its Components, 6th Edition, RSC. 2015.

Teaching Learning Strategies

- Provide updated Lecture Sessions
- Promote Interactive Sessions including discussions and demonstrations.
- Provide experiments to engage students actively and visual aids like presentations, videos, and models to enhance understanding.
- Encourage students to ask questions during or after the lectures

MODE OF TRANSACTION

• Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes.

5. Explain the postulates of kinetic theory
6. Classify the different types of errors.
7. Distinguish between addition and elimination reactions with examples
8. Describe analgesics, tranquilizers, antiseptics with examples.

DISCIPLINE SPECIFIC CORE (DSC)

COORDINATION CHEMISTRY-I

Course Title : **Coordination Chemistry-I**
Course Code : **KU02DSCCHE103**
Course Type : **DSC**
Course credit : **4**
Prerequisites : **Basic concepts of chemical bonding and reaction mechanism**

Course Objectives

- The learners should be able to apply theories of chemical bonding, and stability of coordination complexes to identify reaction mechanism.

Credits			Teaching Hours			Assessment		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
4	0	4	4	0	4	50	50	100

Course Outcomes:

CO1	Understand the basic concepts of coordination complexes.
CO2	Identify the nomenclature, isomerism, stability, structure and reactivity of selected coordination complexes.
CO3	Interpret their chemical reactivity.
CO4	Utilize the principles of transition metal coordination complexes in understanding their chemical reactions.
CO5	Identify the underlying pathways of substitution reactions andRedox reactions in coordination complexes.

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3	3	2	2	3
CO2	3	3	3	3	3	3	3	3	2	3	2	3
CO3	3	2	3	3	3	3	3	2	3	3	3	3
CO4	3	2	3	3	3	3	3	2	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	2	2	3

Module 1 Introduction 15 Hours

Introduction-Double salts and Coordination compounds. Nomenclature. Effective Atomic Number (EAN). Types of ligands. Chelates. Chelate and Macrocyclic effects. Stereo chemistry of coordination compounds with coordination numbers 2 to 6. Isomerism in coordination compounds, Optical and Geometrical Isomerism. Classification of complexes based on coordination numbers and possible geometries, σ and π bonding ligands such as CO, NO, CN-R_3P, and Ar_3P.

Module 2 Stability of complex 15 hours

Stability of complex ions-stability constants. Kinetic and Thermodynamic stability, Stepwise and overall stability constants, Factors affecting the stability of complexes. Irving William order of stability. Application of complex formation in qualitative and quantitativeanalysis.

Module 3 Substitution reactions 15 hours

Reactivity of metal complexes-Labile and inert complexes, Taube mechanism, Kinetics and mechanism of octahedral substitution- water exchange, dissociative, associative and interchange mechanisms, Ligand substitution reactions SN_1 and, SN_2. ligand substitution reactions in square planar and Octahedral complexes, acid hydrolysis, base hydrolysis, SN_1CB mechanism.

Module 4 Electron transfer reactions 15 hours

Electron transfer reactions: Outer sphere mechanism – Marcus' theory, inner sphere and outer sphere reactions, two electron transfer and intramolecular electron transfer reactions, Trans effect and applications of trans effect. Theories of trans effect-polarization and π-bonding theory

References

1. F.A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 6th Edition, Wiley India Pvt. Ltd., New Delhi, 2009 (Reprint).
2. J.E. Huheey, E.A. Keitler and R.L. Keitler, Inorganic Chemistry–Principles ofStructure and Reactivity, 4th Edition, Pearson Education, New Delhi, 2013.
3. D.F. Shriver and P. Atkins, Inorganic Chemistry, 5th Edition, OxfordUniversity Press, New York, 2010.
4 J.D. Lee, Concise Inorganic Chemistry, 5th Edition, Oxford University Press, NewDelhi 2008.
5. R. Gopalan and V. Ramalingam, Concise Coordination Chemistry, 1st Edition, Vikas Publishing House, New Delhi, 2001.
6. W. Pfennig, Principles of Inorganic chemistry. John Wiley & Sons, 2015.
7. K.F. Purcell, J.C. Kotz, Inorganic Chemistry, Holt-Saunders, 1977.
8. B.E. Douglas, D.H. McDaniel, J. J. Alexander, Concepts and Models of Inorganic Chemistry, 3rdEdn., Wiley-India, 2007.
9. J. G. de Vries, C. J. Elsevier, Handbook of Homogeneous Hydrogenations, 3Volumes, Wiley-VCH, 2006.
10. R. G. Wilkins, Kinetics and Mechanisms of Reactions of Transition MetalComplexes, Wiley VCH, 2002

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting Active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminars	10	
	Viva	10	

Sample Questions to test Outcomes

1. Explain optical isomerism in octahedral coordination complexes.
2. Illustrate the concept of stability constant in coordination complexes with suitable example.
3. Differentiate between labile and inert complexes.
4.Give an account of outer sphere mechanism for redox reactions in coordination complexes.

SEMESTER III

DISCIPLINE SPECIFIC COURSE (DSC)

PHYSICAL CHEMISTRY-I

Course Title : Physical Chemistry-I

Course Code : **KU03DSCCHE201**
Course Type : **DSC**
Course Credits : **4**
Pre-requisites : **Should be aware of characteristic properties of matter**

Course Objectives:

- To explore the chemistry of the three phases (solid, liquid and gases) of material and its kinetic aspects.
- To understand the specific aspects of the differences among the three states of matter.
- To understand how molecules and extended solids pack in the solid state in terms of unit cell structures.
- To develop knowledge on with laws of symmetry, Brag'slaw, and crystal defects insolid state.

Credits			Teaching Hours			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

Course Outcome:

C 01	Comprehensive understanding of properties of matter in the gaseous state and crystalline state
C 02	Explain the properties of liquids based on molecular interactions
C 03	Understand the types of packing and imperfections in solids and their role in determining the properties of solids.
C 04	To understand the properties of solids and their possible applications in materials science as superconductors, semiconductors, liquid crystal materials and as magnetic materials.

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**

CO1	2	2	3	3	2	3	1	0	0	2	1	0
CO2	1	3	2	2	3	2	1	0	0	2	1	0
CO3	2	2	1	1	2	2	1	0	0	2	1	0
CO4	3	1	0	1	1	1	1	0	1	2	1	1

Module 1 Gaseous state **15 hours**

1.1 Gas laws – The general gas equation – Mixture of gases – Dalton’s Law – Mole fraction and partial pressure – calculation of partial pressure – 1.2 The Kinetic model of gases – Molecular Speeds – Maxwell’s distribution of molecular speeds – Calculation of most probable velocity, average velocity and root mean square velocity – Average kinetic energy – Collision diameter – Mean free path, Collision number and collision frequency – Degrees of freedom of a gaseous molecule – 1.3 Principle of equipartition of energy and contribution towards heat capacity of an ideal gas.

1.4 Real gases – Molecular attractions – The compression factor – virial equation of state – Van der waals equation expressed in virial form – calculation of Boyle’s temperature – 1.5 Isotherm of real gases and their comparison with Van der waals isotherms –

Module 2 Liquid State and Colloids **15 hours**

2.1 Liquid State: Introduction - Vapour pressure, surface tension and viscosity – 2.2 Explanation on the basis of intermolecular attraction. Refraction: Refractive index Solutions: 2.3 Kinds of solutions – Raoult’s law -Solubility of gases in liquids – Henry's law and its applications – ideal and ideal dilute solution, 2.4 Liquid mixtures- excess functions and regularsolutions. 2.5 Colligative properties - Relative lowering of vapour pressure – Elevation of boiling point – Depression in freezing point-Osmotic pressure - Laws of osmotic pressure – Reverse osmosis and its applications -2.6 Colloidal Chemistry- True solution, colloidal solution and suspension. 2.7 Classification of colloids: Lyophilic, lyophobic, macromolecular, multimolecular and associated colloids with examples. 2.8 Purification of colloids by electrodialysis and ultrafiltration. Properties of colloids: Brownian movement – Tyndall effect – Electrophoresis. 2.9 Origin of charge and stability of colloids – Coagulation - Hardy Schulze rule – Protective colloids - gold number. Emulsions.

Module 3 Solid state **15 hours**

3.1 Solid State: Introduction - Isotropy and anisotropy - Symmetry elements in crystals – The seven crystal systems – space lattice, unit cell, Miller indices - Bravais lattices – Bragg's equation (derivation required) and its applications. Laws of crystallography – Law of constancy of interfacial angles – Law of constancy of symmetry – Law of rationality of indices Isomorphism and polymorphism- Miller indices- diffraction of X-rays-Laue equation- Bragg's Law Determination of internal structure of crystals by X-ray diffraction methods – derivation of Bragg's equation Bragg's rotating crystal method and Debye Scherrer Powder diffraction method, indexing of reflections. Co-ordination Number – Efficiency of packing – Cubic and Hexagonal packing – Radius ratio rule – Tetrahedral and Octahedral voids.

Module 4: Solid State –II **15 hours**

3.2 Defects in solids: Non-stoichiometric and stoichiometric defects - Schottky and Frenkel defects- Extrinsic and intrinsic defects – Metalexcess and metal deficiency – 3.3 Structure of ionic compounds of the type AX (NaCl, CsCl, ZnS) Defects in crystals – stoichiometric and non-stoichiometric defects, extrinsic and intrinsic defects. 3.4 Electrical conductivity, Electronic Properties and Band Theory: Free electron theory to band theory of solids, electrical conductivity, Hall effect. Metals, Insulators and Semiconductors, n-type, p-type.Intrinsic and extrinsic.Superconductivity (Elementary ideas) Liquid crystals(Elementary ideas) -. Magnetic properties: Classification of magnetic materials–dia, para, ferro, ferri, antiferro&antiferri magnetic typesIonic Conductors: Types of ionic conductors, mechanism of ionic conduction, diffusion superionic conductors;

References

1. L VAzaroff, "Introduction to Solids", McGraw Hill, 2017.
2. N B Hannay, "Solid State Chemistry", Prentice Hall, 1967.
3. Anthony R. West, "Solid State Chemistry and its Applications", Wiley Eastern, 2022.
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5. F Daniels and R AAlberty, "Physical Chemistry", 3rd ed. John Wiley and Sons, Inc., New.
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7. Castellan, G.W. "Physical Chemistry",4th Ed. Narosa Publishing House (2018).

8. K. L. Kapoor, “A Textbook of Physical chemistry”, Volume 5, 4th edition, Macmillan India Ltd.
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10. GurdeepRaj, Advanced Physical Chemistry, Goel Publishing House.
11. Liquid Crystals by S. Chandrasekhar F.R.S., Cambridge University Press
12. Magnetism and MagneticMaterials by J. M. D. Coey, Cambridge University Press

Teaching Learning Strategies

- Provide updated Lecture Sessions
- Promote Interactive Sessions including discussions and demonstrations.
- Provide experiments to engage students actively and visual aids like presentations, videos, and models to enhance understanding.
- Encourage students to ask questions during or after the lectures

MODE OF TRANSACTION

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Define viscosity of gas. Show how it varries with temperature.
2. Determine the interplanar spacing between the (221) planes of a cubic lattice of length 4.5Å (450 pm).Which factor is mainly responsible for real gases to show deviation from ideal gases?
3. The vapour pressure of pure water at 26°C is 25.5 torr. What is the vapour pressure of a solution which contains 20.0 glucose, in 100 g water?

DISCIPLINE SPECIFIC COURSE (DSC)

INTRODUCTION TO ORGANIC CHEMISTRY

Course Title	:	**Introduction to Organic Chemistry**
Course Code	:	**KU03DSCCHE202**
Course Type	:	**DSC**
Course Credits	:	**4**
Pre-requisites	:	**Isomerism in organic molecules, organic reactions, soaps, Oils, fats, dyes**

Course Objectives:

- To provide idea about various types of isomerism, their requirements and applications
- To learn about the use of organic chemistry in day-to-day life
- To know about the chemistry of natural products and their applications
- To get an idea about the organic chemical process and their functions in biological systems

Course Outcomes

CO1	Describe the types of stereochemistry, various terminologies and specific notations
CO2	Learn the about the different types of organic substances, their preparation and uses in our life.
CO3	Understand the types of component present in different natural products, their isolation, identification and uses
CO4	Illustrate the biological functions of various metabolites of human such as DNA, RNA, enzymes, etc

Mapping of Course Outcome to POs/PSOs

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	1	2	3	2	1	2	2	2	3	2	1
CO2	2	2	2	3	1	2	1	3	1	1	2	2

CO3	1	3	3	3	2	3	2	1	1	2	2	3
CO4	3	3	2	1	3	1	1	2	3	2	2	1

Module 1 Isomerism 15 hrs

1.1: Structural isomerism, 1.2. Geometrical isomerism, 1.3.Optical isomerism, 1.4.Optical activity and its applications, 1.5.Specific term: Diasteromers, enantiomers and meso compounds, 1.6. Specific term: Steroselective, stereospecific and regioselective syntheses, 1.7. Specific term: Resolution and racemization, 1.8. Walden inversion, 1.9.Absolute and relative configurations, 1.10.R and S notation and its guidelines, 1.11.Cis and trans isomerism. 1.12. E and Z designations, 1.13. Applications of isomerism

Module 2 Chemistry in action 15 hrs

2.1.Oils and fats: properties, 2.2. Hydrogenation of oils and analysis of oils and fats, 2.3.Saponification and iodine values and their determinations, 2.4.Manufacture of vegetable oils, 2.5. Materials used for soaps and detergents, their purposes 2.6. Manufacturing process of soaps and detergents2.7.Action of soaps and detergents, 2.8.Dyes and pigments.Theory of colour and constitution, 2.9.Classification of dyes, 2.10.Natural dyes and methods of extraction, 2.11Mordants and their applications, 2.12Characteristic colours and their compositions, 2.13.Preparation and uses of Azo dyes and indigo, 2.14Paints and organic coatings, 2.15Essential oils

Module 3 Chemistry of natural products 15 hrs

3.1. Alkaloids: Occurrence and extraction, 3.2General properties of alkaloids, 3.3. Exhaustive methylation, 3.4, Structure and isolation of Connine and Piperine, 3.5.Structure and isolation of Nicotine and Atropine, 3.6Terpenes: Isoprene rule3.7. Classification, isolation and general properties of Terpenes, 3.8.Structure and isolation of Citral and Geraniol,3.9.Structure and isolation of Limonine, Menthol and Camphor.3.10. Uses and biological activities of alkaloids and terpenes. 3.11Medicinal importance and toxicity.

Module 4 Bioorganic chemistry 15 hrs

4.1Amino Acids: nomenclature and properties, 4.2. Amino Acids: preparation, 4.3. Peptides and Polypeptides, 4.4Proteins: classification4.5Primary and secondary structures of proteins4.6. The polypeptide chain. Tertiary and quaternary structures of proteins, 4.7.Enzymes and its mechanism of action.4.8. Co- Enzymes. Cofactors and prosthetic groups, 4.9.Denaturation and degradation of proteins, 4.10.Sources and functions of proteins, 4.11.DNA and RNA. Structure and their biological functions

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2. A Text book of Organic Chemistry-Tewari, Vishnoi and Mehrotra, Vikas, New Delhi, (1998).
3. Chemistry of Natural Products – Vol-I & II – O. P. Agarwal, Goel Gorakhpur (1985).
4. Chemistry of Natural Products: A Unified Approach-N R Krishnaswamy University Press (1999)
5. Mechanism and Theory in Organic Chemistry-Lowry and Richardson Harper and Row, (1987).
6. Medicinal Chemistry- G. R. Chatwal, Himalaya (2002).
7. Natural Products Chemistry, Vol-I & II- G.R. Chatwal, Himalaya, (1990).
8. Organic chemistry – J. Clayden, N. Greeves, S. Warren and P. Wothers, Oxford Press (2012)
9. Organic Chemistry 4thEdn.–S.H. Pine, McGraw-Hill, London (1987).
10. Organic Chemistry, Vol I & II, I.L. Finar, Longmann ELBS, London, (1973).
11. Organic Chemistry-P.Y. Bruice, Pearson Education Pvt. Ltd. New Delhi, (2002)
12. Organic Chemistry-Vol.–I & II-Mukherji, Singh and Kapoor, Wiley Eastern, New Delhi, (1985).
13. Organic Reaction Mechanisms- Bansal, Tata McGraw Hill, New Delhi (1978).
14. Stereochemistry of carbon compounds, Ernest Eliel, Tata McGraw Hill, (2001).
15. Stereochemistry, Conformation and Mechanism-P.S. Kalsi, Wiley Eastern, New Delhi (1993).

Teaching Learning Strategies

- Elaborating the requirements of subject
- Providing knowledge about the subject
- Elucidating the know-how with examples
- Catalysing the application of the titled course to the society

Mode of Transactions

• Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Distinguish between diasteroisomers and enantiomers
2. Discuss the action of soaps and detergents
3. What is Exhaustive methylation?
4. Illustrate the mechanism of action of Enzymes

DISCIPLINE SPECIFIC COURSE (DSC)

COORDINATION CHEMISTRY-II

Course Title	:	**Coordination Chemistry-II**
Course Code	:	**KU03DSCCHE203**
Course Type	:	**DSC**
Course credit	:	**4**

Prerequisites : KU02DSCCHE103

Course Objectives

- The learners should be able to understand and apply theories of chemical bonding in electronicstructure elucidation of coordination complexes.

Credits			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

Course Outcomes:

CO1	Understand the preliminarytheories of coordination complexes.
CO2	Identify the principles of crystal field theory and interpret CFSE in d^n complexes.
CO3	Utilize CFSE in interpretation of properties of complexes.
CO4	Identify the principlesMO theory.
CO5	Apply MO theory for construction of Energy level diagram for coordination complexes.

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	3	3	3	3	3	3	3	2	2	3
CO2	3	3	3	3	3	3	3	2	2	3	3	3
CO3	3	3	3	3	3	3	3	2	2	3	3	3
CO4	3	3	3	3	3	3	3	3	3	2	2	3
CO5	3	3	3	3	3	3	3	3	3	3	3	3

Module 1 Preliminary theories of bonding 15 hours

Theories of bonding in transition metal complexes– Werners Theory, Valence Bond theory. Application to some complexes, Hybridization in tetrahedral, square planar and octahedral complexes – explanation of magnetic properties based on VBT. Limitations of VBT.

Module 2: Crystal field theory 15 hours

Crystal field theory, Crystal field stabilization energy (CFSE), Pairing energy, concept of weak and strong fields, Spectrochemical series. Crystal field splitting in octahedral, tetrahedral, square planar, square pyramidal and trigonal bipyramidal geometries. Crystal field splitting in tetragonally distorted octahedral geometry, Jahn-Teller distortion in Cu (II) complexes. Factors affecting the magnitude of crystal field splitting.

Module 3: Applications of crystal field theory **15 hours**

Factors influencing CFSE, Effect of CFSE in ionic radii, Lattice energy and enthalpy of first row transition elements. Explanation of colour, spectral and magnetic properties. Limitations of CFT

Module 4: MO theory **15 hours**

MO theory, evidence for metal ligand covalency, Energy level diagrams-MO diagram of complexes of octahedral, tetrahedral and square planar complexes (sigma bonding only), Evidences for metal-ligand overlap; sigma and pi bonding in complexes. Molecular Orbital theory - diagrams for octahedral complexes with π-bonding, experimental evidences for π - bonding.

References

1. F.A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 6th Edition, Wiley India Pvt. Ltd., New Delhi, 2009 (Reprint).
2. J.E. Huheey, E.A. Keitler and R.L. Keitler, Inorganic Chemistry–Principles of Structure and Reactivity, 4th Edition, Pearson Education, New Delhi, 2013.
D.F. Shriver and P. Atkins, Inorganic Chemistry, 5th Edition, Oxford University Press, New York, 2010.
4 J.D. Lee, Concise Inorganic Chemistry, 5th Edition, Oxford University Press, New Delhi 2008.
5. R. Gopalan and V. Ramalingam, Concise Coordination Chemistry, 1st Edition,NVikas Publishing House, New Delhi, 2001.
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8. J. A. Cowan, Inorganic Biochemistry: An Introduction, VCH Publishing, 1993.
9. W. Kaim, B. Schwederski, B. Bioinorganic chemistry: Inorganic Elements in the Chemistry of Life, Wiley, 2006
11. G. A. Lawrance, Introduction to Coordination Chemistry, John Wiley & Sons Ltd, 2010.
12. C. E. Housecroft, A. G. Sharpe, Inorganic Chemistry, Pearson, 2012.

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting Active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminars	10	
	Viva	10	

Sample Questions to test Outcomes

1. Write down the postulates of Werners theory.
2. Calculate CFSE for d^n system.
3. Comment on the trends in lattice energy and enthalpy of hydration for first row transition metal ions.
4. Discussenergy level diagram for sigma bonded octahedral ML_6 complexes according to MO theory.

DISCIPLINE SPECIFIC COURSE (DSC)
INORGANIC CHEMISTRY PRACTICAL-I

Course Title	:	**Inorganic Chemistry Practical-I**
Course Code	:	**KU03DSCCHE204**
Course Type	:	**DSC**
Course credit	:	**4**
Prerequisites	:	**General Safe Laboratory practices, Basic inorganic analysis**

Course Objectives:

- The course provides opportunities for hands –on laboratory experiences related to qualitative and quantitative inorganic analysis

Credits			Teaching Hours			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

Course Outcomes:

CO1	Perform basic chemical lab procedures by following appropriate lab safety measures & infer the experimental results with mathematical and analytical reasoning.
CO2	Separation and identification of mixture of cations in a given sample
CO3	Estimation of the content of metal ion present in the whole of the given solution.
CO4	Preparation and characterisation of inorganic complexes
CO5	**Plan** and **Conduct** experiments for identification and characterisation of inorganic compounds.

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Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3	3	3	2	3
CO2	3	3	3	3	3	3	3	3	3	3	2	3
CO3	3	3	3	3	3	3	3	3	3	3	2	3
CO4	3	3	3	3	3	3	3	3	3	3	2	3
CO5	3	3	3	3	3	3	3	3	3	3	2	3

Module 1: Volumetric analysis **30 hours**

0. **Introduction to volumetric analysis**
   a. Relation of acid-base titrations with real life situations like estimation of citric acid in citrus fruits like lemon, orange etc.
   b. Equivalent and molecular mass of compounds. Normality and Molarity – Primary standards. Preparation of standard solution – Principles of volumetric analysis.
   c. For acidimetry, alkalimetry and permanganometry two burette method may be used and for other volumetric analyses conventional methods can be used.

1. **Acidimetry and Alkalimetry**
   a. Estimation of NaOH using standard Na2 CO3 (two burette method).
   b. Estimation of HCl using standard oxalic acid (two burette method).
   c. Estimation of bicarbonate and carbonate in a mixture.

2. **Permanganometry**
   a. Estimation of oxalic acid – using standard Mohr's salt (Two burette method).
   b. Estimation of Fe^{2+} using standard oxalic acid (two burette method).
   c. Estimation of Ca^{2+}
   d. Estimation of nitrite.
   e. Estimation of percentage of Mn in pyrolusite.
   f. Estimation of hydrogen peroxide.

3. **Dichrometry**
   a. Estimation of Fe^{2+} - External indicator.

b. Estimation of Fe^{3+} - Reduction of SnCl2-Internal indicator.
c. Estimation of Fe^{2+} using internal indicator.

4. **Iodometry and iodimetry**
a. Estimation of Cu^{2+}/$CuSO_4.5H_2O$
b. Estimation of Potassium dichromate/Cr^{3+}
c. Estimation of As_2O_3/As^{3+}

5. **Precipitation titration – using adsorption indicators**
a. Estimation of chloride in neutral medium.

6. **Complexometry**
a. Estimation of Mg^{2+}
b. Estimation of Zn^{2+}
c. Determination of total hardness of water

7. **Practical applications of titration in real life**
a. Estimation of citric acid in lemon or orange.
b. Determination of acetic acid content in Vinegar by titration with NaOH.
c. Determination of alkali content in antacid tablets by titration with HCl.
d. Determination of COD of water samples
e. Determination of hardness of water
f. Rancidity of oils by iodometry.

Module 2: Gravimetric analysis **30 hours**

Introduction to gravimetric techniques and its highlights.

1. Determination of water of hydration in crystalline barium sulphate.
2. Determination of Ba^{2+} as $BaSO_4$
3. Determination of sulphate as $BaSO_4$
4. Determination of Fe^{2+} as Fe_2O_3
5. Determination of Ca^{2+} as $CaCO_3$
6. Estimation of Ni^{2+} as Nickel dimethylglyxomite.
7. Determination of Cu^{2+} as cuprous thiocyanate.
8. Determination of Mg^{2+} as magnesium oxinate.

Module 3: Inorganic Qualitative Analysis **30 hours**

(1) Systematic qualitative analysis of a mixture containing two cations and two anions bysemi-micro method

Study of the reactions of the following ions with a view to their identification and confirmation: Lead, Silver, Mercurous mercury, Mercuric mercury, Bismuth, Copper, Tin,Antimony, Iron, Aluminium, Chromium, Zinc, Manganese, Cobalt, Nickel, Barium, Strontium,Calcium, Magnesium, and Ammonium.

Carbonate, Acetate, Oxalate, Fluoride, Chloride, Bromide, Iodide, Nitrate, Sulphate,Borate, Phosphate, Chromate, Arsenate, Arsenite.

Note : Minimum ten mixtures should be analyzed and recorded.

Module 4: Preparations **30 hours**

[Any three of the following inorganic preparations]

(1) Ferrous ammonium sulphate.
(2) Tetraamminecopper(II) sulphate.
(3) Potassium trisoxalatochromate(III).
(4) Potassium alum $KAl(SO_4)_2.12H_2O$
(5) Hexaamminecobalt(III) chloride.

Reference

1. C. N. R. Rao, U. C. Agarwal, Experiments in General chemistry, Affiliated East-West Press, 1973
2. G H Jeffery, J Bassett, J Mendham, R. C. Denney, Vogel's Textbook of Quantitative Chemical Analysis, 5thEdn, Longman,1989.
3. A. I. Vogel, G. Svehla: Vogel's Qualitative Inorganic Analysis, 7thEdn, Longman,1996.
4. W. L. Jolly, The Synthesis & characterization of Inorganic Compounds, Prentice Hall. 1970
5. G. Pass, H. Sutcliffe, Practical Inorganic Chemistry; John Wiley and Sons,1979.
6. D.M Adams, J.B. Raynor, Advanced Practical Inorganic Chemistry; Wiley, 1965.
7. G.Braurer, Hand Book of Preparative Inorganic Chemistry, 2ndEdn, Vols,1-2. Academic Press, 1963.

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting Active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminars	10	
	Viva	10	

Sample Questions to test Outcomes:

1. Estimate the amount of metal ion present in the whole of the given solution using volumetry.
2. Estimate the amount of metal ion present in the whole of the given solution using gravimetry.
3. Separate and identify mixture containing two cations and two anions.
4. Prepare tris(thiourea) copper(I) complex according to given procedure.

SEMESTER IV
DISCIPLINE SPECIFIC COURSE (DSC)

CONCEPTUAL ORGANIC CHEMISTRY

Course Title	:	**Conceptual Organic Chemistry**
Course Code	:	**KU03DSCCHE204**
Course Type	:	**DSC**

Course credit : **4**

Prerequisites : **Stereochemistry, reaction intermediates, basic rules in organic chemistry**

Course Objectives:

- To learn the basics of the formation of organic chemistry reactions
- To know about the various paths of organic reactions leading the formation of products
- To study the different types of isomerism exhibited by organic molecules
- To understand the different methods of organic synthesis

Course Outcomes

CO1	Describe the theoretical aspects of organic molecules to predict the feasibility of reactions
CO2	Understand the various steps involving in product formation in organic reactions
CO3	Apply the rules and regulations of stereo chemical aspects to organic molecules
CO4	Illustrate the ease of organic synthesis through new, ecponomical and environment friendly approaches

Mapping of Course Outcome to POs/PSOs

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	3	2	3	2	1	2	3	2	1	2
CO2	3	2	3	2	2	3	2	3	3	3	1	3
CO3	3	1	2	1	1	1	3	1	2	2	2	1
CO4	3	1	2	1	3	3	1	2	1	1	3	1

Module 1 **Theoretical Organic Chemistry** **15 hrs**

1.1.Localized and delocalized chemical bonding, 1.2. Resonance, bond energy and polarizabilty.1.3. Molecular Orbital Theory and Huckel MOT. 1.4. Assumptions, limitations and applications of HMOT, 1.5. Aromaticity- Types of aromaticities - anti, homo and non-aromaticity, 1.6. Aromaticity- Examples and comparison of properties, 1.7.Aromaticity of four, five and six membered heterocyclic compounds,1.8.Aromaticity of fused rings, charged rings and annulenes, 1.9. Hammett equation and plots ,1.10. Limitations of and deviations from

Hammet plots, 1.11.Significance and applications of Hammett plots Electronic and steric effects, 1.12.Influence of structural features on acidity, basicity and reactivity of organic compounds.1.13. Electron displacement effects - inductive, electromeric, mesomeric (resonance) and hyper-conjugation

Module 2 Path of Organic Reactions 15 hrs

2.1. Carbocations: Generation, structure, detection, stability and reactions of carbocations, 2.2

Classical and non-classical carbocations, 2.3.Carbanions: Geometry, occurrence and properties of carbanions, factors affecting the stability of carbanions, main reactions of carbanions, Carbon acids, 2.4. Radicals: Carbon free radicals: Generation, stability and reactions of radicals, 2.5. Diradicals: Structure and generation of carbenes Addition and insertion reactions and rearrangement reactions of carbenes.2.6. Structure of nitrene, generation and reactions of nitrene 2.7. Formation and reactions of benzynes, 2.8.Chemistry of enolates and enamines.2.9. Nucleophile substitution: S_N1, S_N2 and S_Ni reactions-mechanisms stereochemistry - effect of solvent, structure of substrate, 2.10. Nucleophilicity of the reagent [nucleophile] and nature of the leaving group, 2.11.Elimination reactions: E1, E2 and E1CB reactions and mechanisms, 2.12. Hofmann and Saytzeff rules. 2.13. Elimination vs Substitution,

Module 3 Stereochemistry 15hrs

3.1.Introduction to isomerism: Chirality of molecules devoid of chiral centres, 3.2. Restricted rotation and asymmetry, Atrop isomerism, 3.3.Molecules with planar chirality: annulenes, 3.4. Stereochemistry of allenes, spirans, metallocenes and helicenes, 3.5.Enantiomeric and diastereomeric excess, 3.6. Reactivity in acyclic compounds, stereochemistry of three, four and five membered cycloalkanes, 3.7.Stereochemistry of cyclohexane, fused rings and bridged compounds, 3.8. Cram-Chelate, Felkin-Ahn, anti-Felkin, Houk models, Cieplak and cation coordination models, 3.9.Stereo selective synthesis and asymmetric synthesis, 3.10.Chiral auxiliaries, methods of asymmetric induction, 3.11.Stereochemistry of organic compounds other than carbon centre. 3.12. Introduction to optical rotation and optical rotatory dispersion, circular dichroism, 3.13. Cotton effect and their application in assigning configuration and conformation, 3.14.Octant and axial haloketone rules

Module 4 **Methods of Organic Synthesis** **15 hrs**

4.1.Applications of the Green strategies in organic synthesis, 4.2.Need for Green chemistry, evolution of Green Chemistry, principles of Green Chemistry, 4.3. Classification of organic reactions under Green chemistry principles, 4.4.Atom economic and non-toxic byproductreactions, 4.5.Alternative/Green Solvents for Organic Synthesis, Water, Ionic liquids, Supercritical liquids and PEG, 4.6. Microwave assisted organic synthesis, examples, advantages and disadvantages, 4.7. Phase transfer catalysis, Protective groups in organic synthesis, 4.8. Protection of hydroxyl, carboxyl, carbonyl, amino groups.Protection of carbon-carbon multiple bonds.4.9. Illustration of deprotection in synthesis. 4.10. Organic reaction pathways, factors affecting the reaction yields, design of reaction conditions, solvents and apparatus, monitoring of reactions, 4.11. Thin layer chromatography, search of solvent combinations and ratio, purification, 4.12. Methods for determination of reaction mechanism

References:

1. A Guidebook to Mechanisms in Organic Chemistry, P. Sykes, Pearson Education (2003)
2. Advanced Organic Chemistry: Part A: Structure and Mechanisms, Francis A. Carey, Richard J. Sundberg, Springer (2007)
3. Dynamic Stereochemistry of Chiral Compounds Principles and Applications, Christian Wolf, RSC publications (2007)
4. Green Chemistry: An introductory text by Mike Lancaster, RSC publishing, 2nd Edition, (2010)
5. Green Chemistry: Theory and Practice by Paul T. Anastas and John C. Warner, Oxford University Press, Oxford, (1998)
6. Introduction to stereochemistry, Andrew Clark, RSC publications (2020)
7. Introduction to stereochemistry, K. Mislow, Dower Publications (2003)
8. Introduction to strategies for organic synthesis, Starkey L S, John Wiley and Sons (2018)
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15. Organic stereochemistry, M.J.T. Robinson, Oxford Publications (2001)
16. Organic Synthesis, Michael B Smith, 2nd Edition, (2005)
17. Organic synthesis: Special techniques, V.K. Ahluwalia and R. Agagrwal, Narosa (2001)
18. Phase Transfer Catalysis in Organic Synthesis, William P. Weber, ,George W. Gokel Springer –Verlag (1997)
19. Principles of Organic Chemistry, T. A. Geissman, W.H. Freeman & Co Ltd; 4th edition, (1977)
20. Stereochemistry of carbon compounds, Ernest Eliel, Tata McGraw Hill, (2001)
21. The Search of organic reaction pathways, P. Sykes, John Wiley & Sons (1972)

Teaching Learning Strategies

- Making awareness about the subject
- Affording knowledge about the subject
- Facilitating the use of know-how with examples
- Developing the application of the titled course to the society

Mode of Transactions

• Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Discuss the limitations and applications of HMOT
2. Discuss the formation and reactions of benzynes
3. Explain the Cram-Chelate and Felkin-Ahn models
4. What is a phase transfer Catalyst? What are their applications?

DISCIPLINE SPECIFIC COURSE (DSC)

PHYSICAL CHEMISTRY II

Course Title	**: Physical Chemistry-II**
Course Code	**: KU04DSCCHE206**
Course Type	**: DSC**
Course Credits	**: 4**
Pre-requisites	**: Elementary knowledge in thermodyamics**

Course Objectives:

- To describe the concepts of thermodynamics and their applications
- To know the fundamentals of Thermodynamics including thermodynamic systems and properties, relationships among the thermo-physical properties, the

laws of thermodynamics and applications of these basic laws in thermodynamic systems.

Credits			TeachingHours			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

Course Outcome:

C 01	Apply thermodynamic principles to solve practical problems in physical and chemical systems.
C 02	Describe the concepts of chemical thermodynamics.
C 03	Able to explain the energy changes associated with various process around and predict the feasibility of a process or reaction in scientific way
C 04	Understand the concept of entropy,
C05	Explain the fundamental laws of thermodynamics and its application in isothermal, adiabatic and Joule-Thomson expansion processes.

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	2	1	3	3	0	1	0	2	2	1
CO2	3	2	2	1	3	3	1	1	0	1	2	1
CO3	2	3	2	1	3	3	0	2	1	2	2	1
CO4	3	3	2	1	3	3	0	2	1	2	2	1
CO5	2	3	2	1	3	3	0	1	0	1	2	1

Module 1 Thermodynamics-I **15 hours**

1.1 The first Law – the basic concepts – System – surrounding – process – open, closed and isolated system – Isothermal, Isochoric and Isobaric process – work – Heat – Energy – Internal energy – 1.2 The statement of first law – the conservation of energy – Expansion work – general expression of work – free expansion – Expansion against constant pressure – reversible expansion – 1.3 Heat capacity at constant volume (Cv) and at constant pressure (Cp) – relation between Cp and Cv – 1.4 Thermodynamic derivation – Enthalpy definition and measurement – Adiabatic change –work of adiabatic change.

Module 2 Thermo chemistry **15 hours**

2.1 Standard enthalpy changes – Enthalpies of physical change – Enthalpy of vapourisation, enthalpy of transition and enthalpy of fusion – enthalpy chemical changes –2.2 Thermo chemical equation – Standard enthalpy of reaction, combustion and formation –Temperature dependence of reaction enthalpies Kirchoff's law. –2.3 State functions and exact differentials – state and path functions – exact and inexact different differentials – internal pressure – measurement of internal pressure – 2.4 Joule experiment Changes in enthalpy at constant volume – isothermal compressibility – Joule – Thomson effect – inversion temperature.

Module 3Thermodynamics-II **15 hours**

3.1 The Second Law – the concepts – Spontaneous and non-spontaneous process – 3.2 statement of second law – Entropy – Thermodynamic definition – Entropy as a state function – 3.3 Carnot cycle – the Thermodynamic scale of temperature – 3.4 Entropy changes accompanying phase transitions –variation of entropy with temperature – 3.5 the Helmholtz and Gibbs free energies – their significance– 3.6 Maxwell's relations – Criteria of spontaneity – Gibbs – Duhem equation – Clausius –Clapyeyron equation applicable to solid – liquid, solid-vapour and liquid-vapourequilibria.

Module 4 Thermodynamics-III **15 hours**

4.1 Third Law of thermodynamics – The Nernst heat theorem – Absolute entropy – 4.2Calculation of absolute entropies of elements and compounds- Experimental verification of third law- 4.3 Entropies of real gases- Entropy change in Chemical Reactions- 4.4 Residual entropy.4.5 Zeroth law of thermodynamics

1. Gurdeep Raj, Advanced Physical Chemistry, Goel publishing house.
2. S. H. Marron and J. B. Lando, Fundamentals of Physical Chemistry, Macmillan Ltd.
3. G. K. Vemulapalli, Physical Chemistry, Prentice-Hall of India Pvt. Ltd.
4. Puri, Sharma and Pathania, "Principles of Physical Chemistry", 48th Edition, Vishal Publishing Company
5. Castellan, G.W. "Physical Chemistry",4th Ed. Narosa Publishing House (2018).
6. K. L. Kapoor, "A Textbook of Physical chemistry", Volume 5, 4th edition, Macmillan India Ltd.,
7. R P W Atkins, "Physical Chemistry", Oxford University Press (12th Edition)
8. Barrow, G.M. "Physical Chemistry", Tata McGraw-Hill (2007).

9. D. A. McQuarrie, J. D. Simon, Physical Chemistry – A molecular Approach, Viva Books Pvt. Ltd

10. Puri, Sharma and Pathania, "Principles of Physical Chemistry", 48th Edition, Vishal Publishing Company

11. F Daniels and R AAlberty, "Physical Chemistry", 3rd ed. John Wiley and Sons, Inc., New.

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13. Castellan, G.W. "Physical Chemistry",4th Ed. Narosa Publishing House (2018).

14. K. L. Kapoor, "A Textbook of Physical chemistry", Volume 5, 4th edition, Macmillan India Ltd.,

15. D. A. McQuarrie, J. D. Simon, Physical Chemistry – A molecular Approach, Viva Books Pvt. Ltd.

16. Glasstone and Lewis, Elements of Physical Chemistry, Macmillan

Teaching Learning Strategies

- Provide updated Lecture Sessions
- Promote Interactive Sessions including discussions and demonstrations.
- Provide experiments to engage students actively and visual aids like presentations, videos, and models to enhance understanding.
- Encourage students to ask questions during or after the lectures

MODE OF TRANSACTION

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

4. Define a thermodynamic system.
5. Discuss about thermodynamic equilibrium?
6. Discuss aboutMaxwell's relation and its significance?

DISCIPLINE SPECIFIC COURSE (DSC)

COORDINATION CHEMISTRY-III

Course Title	:	**Coordination Chemistry-III**
Course Code	:	**KU04DSCCHE207**
Course Type	:	**DSC**
Course credit	:	**4**
Prerequisites	:	**Electronic configuration of transition metal ions**

Course Objectives

- The learners should be able to apply electronic structure and magnetism of coordination complexes to interpret their electronic spectra and magnetic behaviour.

Credits			Teaching Hours			Assessment		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
4	0	4	4	0	4	50	50	100

Course Outcomes:

CO1	Use term symbols and selection rules to plot Orgel diagrams and Tanabe-Sugano diagrams.
CO2	Interpret electronic spectra of d^n ions.
CO3	Identify and apply the principles of various spectroscopic techniques for analysis of coordination complexes.
CO4	Identify magnetic behavior of complexes.
CO5	Interpret magnetic properties of complexes.

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	2	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	2	2	3
CO5	3	3	3	3	3	3	3	2	3	3	3	3

Module 1: Term symbols and Selection rules 15 hours

Spectroscopic Term symbols for dn ions - derivation of term symbols and ground state term symbol, Hund's rule; Selection rules – break down of selection rules, spin- orbit coupling, band intensities, weak and strong field limits- correlation diagram; Energy level diagrams; Orgel and Tanabe-Sugano diagrams; Evaluation of Dq and B values.

Module 2: Electronic spectroscopy 15 hours

Spectral properties of metal complexes-d-d transition, splitting of terms in weak and strong octahedral and tetrahedral fields, Nephelauxetic effect, Racah parameters, selection rules for electronic transitions, Electronic spectra of metal complexes and their interpretation. electronic absorption spectrum of d^1 to d^9 ions Charge transfer spectra. Charge transfer spectra e.g. $KMnO_4$, $K_2Cr_2O_7$ (Elementary idea), Electronic spectra of lanthanide and actinide complexes.

Module 3: Miscellaneous Spectroscopy of coordination complexes 15 hours

Optical activity of coordination compounds, ORD and CD, Cotton effect and applications. IR spectra of metal complexes, NMR spectroscopy for structuralinvestigation of diamagnetic metal complexes from chemical shift and spin-spin coupling. EPR spectra of metal complexes – hyperfine splitting, g-values, zero field splitting and Kramer's degeneracy. Applications to copper (II) complexes. Mossbauer spectra – application to iron complexes, Mossbaur effect, hyperfine interactions, isomer shift, electric quadrupole and magnetic hyperfine interactions. Importance of molar conductance measurements in coordination chemistry.

Module 4: Magnetism 15 hours

Magnetic properties of complexes - Types of magnetic behaviour, spin-only magnetic moment, calculation of magnetic moments. paramagnetic and diamagnetic complexes, diamagnetic corrections, molar susceptibility, Gouy method for the determination of magnetic moment of complexes, Temperature dependence of magnetism- Curie's law, Curie- Weiss law, temperature independent paramagnetism (TIP)

References

1. F.A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 6th Edition, WileyIndia Pvt. Ltd., New Delhi, 2009 (Reprint).
2. J.E. Huheey, E.A. Keitler and R.L. Keitler, Inorganic Chemistry–Principles ofStructure and Reactivity, 4th Edition, Pearson Education, New Delhi, 2013.
3. D.F. Shriver and P. Atkins, Inorganic Chemistry, 5th Edition, Oxford UniversityPress, NewYork, 2010.

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5. R. Gopalan and V. Ramalingam, Concise Coordination Chemistry, 1st Edition, Vikas Publishing House, New Delhi, 2001.

6. B. D. Guptha, A. J. Elias BaiscOrganomettalic Chemistry, Concepts , Synthesis and Applications, 2nd Edition, University Press.

7. I. Bertini, H. B. Gray, S. J. Lippard, J. S. Valentine, Bioinorganic chemistry, University Science Books, 1994.

8. J. A. Cowan, Inorganic Biochemistry: An Introduction, VCH Publishing, 1993.

9. W. Kaim, B. Schwederski, B. Bioinorganic chemistry: Inorganic Elements in the Chemistry of Life, Wiley, 2006.

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting Active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminars	10	
	Viva	10	

Sample Questions to test Outcomes

1. Derive term symbol for d^2 ion.Draw orgel diagram for d^2 ion.
2. Why did $KMnO_4$ exhibit vivid purple colour?
3. Comment on EPR spectra for Cu(II) ion.
4. Give an account of magnetic moment for first row transition metal ions.

DISCIPLINE SPECIFIC COURSE (DSC)

PHYSICAL CHEMISTRY PRACTICAL-I

Course Title	:	**Physical Chemistry Practical-I**
Course Code	:	**KU04DSCCHE208**
Course Type	:	**DSC**
Course Credits	:	**4**
Pre-requisites	:	**Basic analytical techniques**

Course Objectives:

- To impart practical knowledge of equilibrium and electrochemical aspects of different systems.
- To understand the various analytical methods of analysisusing colorimetry, conductometry, and pH metric method
- To study the adsorption rates of various systems by using adsorption isotherm.
- To explore the chemistry of the three phases (solid, liquid, and gases) of material and kinetic aspects of chemical reactions.

Credit			Teaching Hours			Assessment		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
0	4	4	0	4	4	50	50	100

Course outcomes:

C01	Evaluate the distribution co-efficient of a compound between two immiscible solvents
C02	Construct a phase diagram of a binary system
C03	Perform conductometric titration to determine the unknown concentration of solutions
C04	Determine unknown concentration by colorimetric method
C05	To analyze the rate of the different chemical reactions and determine the reaction's order.

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	2	3	3	2	2	2	3	1	3
CO2	3	3	3	2	3	3	2	2	2	3	1	3
CO3	3	3	3	2	3	3	2	2	2	3	1	3
CO4	3	3	3	2	3	3	2	2	2	3	1	3
CO5	3	3	3	2	3	3	2	2	2	3	1	3

Module I Chemical Kinetics and Distribution law 30hrs

1.1 Determination of specific reaction rate of the hydrolysis of methyl acetate catalysed by hydrogen ion at room temperature.

1.2 Determination of overall order of saponification of ethyl acetate.

1.3 Determination of distribution coefficient of iodine between water and carbon tetrachloride.

1.4 Determination of the distribution coefficient of benzoic acid in toluene and water.

Module II Electrochemistry and Colorimetry 30hrs

2.1 Determination of concentration of HCl conductometrically using standard NaOH solution.

2.2 Determination of concentration of acetic acid conductometrically using standard NaOH solution.

2.3 Preparation of alkaline buffer solutions.

2.4 pH metric titration of weak acid (acetic acid) with strong base NaOH and calculation of dissociation constant.

2.5 Verification of Beer-Labert law for $KMnO_4$, $K_2Cr_2O_7$ and determination of the concentration of the given solution.

Module III Adsorption and Phase rule 30hrs

3.1 Adsorption of acetic acid, oxalic acid on animal charcoal, verification of Freundlich isotherm.

3.2 Determination of CST of phenol – water system.

3.3 Determination of Transition temperature of salt hydrates (Sodium thiosulphate, sodium acetate)

3.4 Determination of unknown concentration of KCl/Succinic acid using CST method

3.5 Construction of phase diagram of simple eutectics (Naphthalene-Biphenyl System)

Module IV Molecular weight determination 30hrs

4.1 Determination of molecular weight by Rast's method

4.2 Determination of the identity oftwo compounds by mixed melting points. (Using naphthalene, biphenyl or camphor as solvent and acetanilide, p-dichlorobenzene etc. as solute).

References

1. A.I.Vogel - A Text Book of Qualitative Analysis including semi-micro methods

2. V.V.Ramanujan – Semi micro Qualitative Analysis.

3. A.I.Vogel – A Text Book of Quantitative Inorganic Analysis.

4. A.I.Vogel - Elementary Practical Organic Chemistry.
5. A.O.Thomas – Practical Chemistry for B.Sc Chemistry.
6. A Findlay – Practical Physical Chemistry.
7. R.C.Das & E Behara – Experimental Physical Chemistry.
8. N.K.Vishnoi – Advanced Practical Chemistry.

Teaching Learning Strategies

- Provide experiments to engage students actively and visual aids like presentations, videos, and models to enhance understanding.
- Encourage students to ask questions during or after the practical.
- Allow students to conduct experiments under supervision.
- Provide students with the required safety instructions and guidelines for lab work

MODE OF TRANSACTION

• Discussions and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External lab Exam	50	50
Continuous Evaluation	Internal lab Exam	40	50
	Viva	10	

Sample Questions to test Outcomes.

1) Determine the molecular mass of the given compound by Rast's method
2) Determine the concentration of HCl by conductometric titration method.
3) Determine the concentration of $KMnO_4$ or $K_2Cr_2O_7$ by colorimetry.
4) Determine the rate of the hydrolysis of methyl acetate.

SEMESTER V
DISCIPLINE SPECIFIC COURSE (DSC)
ORGANIC CHEMISTRY PRACTICAL I

Course Title	:	**ORGANIC CHEMISTRY PRACTICAL I**
Course Code	:	**KU05DSCCHE301**
Course Type	:	**DSC**
Course Credits	:	**4**
Pre-requisites	:	**Organic synthesis, Reactions and Basics of chromatography**

Course Objectives:

- To experience the synthesis of organic named reactions

- To be able to do the organic estimations
- To study the basics of chromatography and allied techniques of purifications
- To study the identification of organic groups through chemical reactions

Credit			Teaching Hours			Assessment		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
0	4	4	0	4	4	50	50	100

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

C01	Separate the organic mixtures into single components
C02	Identify organic compound using group identification tests
C03	Prepare new compounds applying many reactions and identify them using physical parameters
C04	Handle and carryout many laboratory identification methods such as chromatography and distillation, etc

Mapping of Course Outcomes to POs/PSOs:

	PSO 1	PSO 2	PSO 3	PSO 4	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
C0 1	3	2	3	3	2	3	1	1	1	2	1	2
C0 2	3	2	3	3	2	3	1	1	1	2	1	2
C0 3	3	2	3	3	2	3	1	1	1	2	1	2
C0 4	3	2	3	3	2	3	1	1	1	2	1	2

Module 1 **Distillation** **30 hours**

Simple distillation, vacuum distillation, fractional distillation, boiling point determination of compounds.

Module 2 **Organic Preparations** **30 hours**

Bromination, Nitration, Diazotization, Acetylation, TLC, melting point determination, recrystallization.

Module 3 **Solvent Extraction** **30 hours**

1. Aniline from water. 2. Methyl benzoate from water. (Use ether and record the yield recovery)

Module 4 **Reactions of Organic Compounds** **30 hours**

Functional group determination: 1. Phenols. 2. Nitro compounds. 3. Amines. 4. Halogen compounds. 5. Aldehydes and ketones. 6. Carboxylic acid. 7. Carbohydrates. 8. Amides. 9. Esters. 10. Hydrocarbons.

References

1. B. S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, Vogel's Textbook of Practical Organic Chemistry, 5th Edn., Pearson Education, Noida, 2014.
2. F. G. Mann, B. C. Saunders, Practical Organic Chemistry, 4th Edn., Pearson Education, Noida, 2011.
3. Arthur I. Vogel, Elementary Practical Organic Chemistry- Small Scale Preparations, 2nd Edn., Pearson Education, Noida, 2013.
4. V. K. Ahluwalia, S. Dhingra, Comprehensive Practical Organic Chemistry, Universities Press, Hyderabad, 2004.

Teaching Learning Strategies

- Provide experiments to engage students actively and visual aids like presentations, videos, and models to enhance understanding.
- Encourage students to ask questions during or after the practical.
- Allow students to conduct experiments under supervision.
- Provide students with the required safety instructions and guidelines for lab work

Mode of transaction

- Discussions and demonstrations.

ASSESSMENT RUBRICS			Total
End Semester Evaluation	**External Exam**	**50**	**50**
Continuous Evaluation	**Internal Exam**	**40**	**50**
	Viva	**10**	

Sample Questions to test Outcomes.

1. Explain the Bromination reaction with example.
2. What is diazotization reaction?
3. Discuss the various precautions to be taken for bromination experiment.
4. Illustrate the procedure for the nitration of acetanilide.
5. Explain the principle of solvent extraction and mention any two application of solvent extraction .

DISCIPLINE SPECIFIC COURSE (DSC)

REACTIVE ORGANIC CHEMISTRY

Course Title	**:**	**Reactive Organic Chemistry**
Course Code	**:**	**KU05DSCCHE302**
Course Type	**:**	**DSC**
Course Credits	**:**	**4**
Pre-requisites	**:**	**Organic reactions, mechanistic pathways, types of organic : reactions, stereochemistry,**

Course Objectives:

- To learn the about various common organic reactions and their mechanisms
- To study the organic rearrangement reactions and their mechanism
- To describe about the heterocyclic compounds of different ring sizes
- To understand the types and theoretical pathways of photochemical and pericyclic reactions

Course Outcomes

CO1	Describe the organic reactions and their mechanisms
CO2	Illustrate the mechanistic aspects of organic named rearrangement reactions
CO3	Study the synthesis and chemical reactions of different heterocyclic compounds
CO4	Analyse the requirements for photochemical and pericyclic reactions

Mapping of Course Outcome to POs/PSOs

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	1	1	2	2	1	1	2	2	3	1	2	1
CO2	1	2	3	3	2	1	2	3	1	3	1	1
CO3	1	2	3	2	3	1	3	2	2	2	3	1
CO4	1	2	3	1	3	2	3	1	3	2	1	2

Module 1 **Reaction Mechanisms** **15 hrs**

1.1Mechanisms of nucleophilic aliphatic substitution, 1.2Mechanism of electrophilic aliphatic and aromatic substitution, 1.3Mechanisms of organic reactions: Michael, Stobbe and Darzen reactions, 1.4Mechanisms of Dakin, Mannich and Cannizzarro reactions, 1.5

Condensation reactions: Mechanisms and applications of Aldol, Benzoin, Knoevenagel and Claisen condensations, 1.6Coupling reactions: Mechanisms and applications of Negishi, Sonogashira, Heck, Suzuki and Ullmann coupling reactions, 1.7Oxidation and Reduction reactions, 1.8Mechanisms and applications of Baeyer-Williger and Oppenauer oxidations,

1.9, Mechanisms and applications of Birch reduction and Clemenson reduction

Module 2 **Rearrangement reactions** **15 hrs**

2.1Amine formation reactions: Mechanisms and application of Hoffmann, Lossen, Schmidt and Curtius rearrangements2.2Reactions involving migration of groups: Mechanisms and application of Dienone-phenol, Fries, Fischer - Hepp and Classien rearrangements2.3Reactions involving insertions: Mechanisms and application of Beckmann, Demjanov, Benzilic acid, Favorskii and Di-pi methane rearrangements2.4Reactions involving formation of new groups: Mechanisms and application of Bamberger, Wagner- Meerwein and von Richer rearrangements2.5Reactions involving Nitrogen groups: Mechanisms and application of rearrangement reactions: Sommelet- Hauser and Stevens rearrangements

Module 3 **Heterocyclic chemistry** **15 hrs**

3.1Introduction to heterocyclic compounds, 3.2Nomenclature of Heterocyclic compounds, 3.3Three and four membered heterocycles, 3.4. Five membered heterocyclic compounds: Synthesis and reactions of pyrrole furan and thiophene, 3.5. Six membered heterocyclic compounds: Synthesis and reactions of pyridine, pyran and thiopyran, 3.6Fused rings: Synthesis and reactions of indole, quinoline, isoquinoline and benzofuran, 3.7Heterocyclic compounds with more than one hetero atoms: chemistry of pyramidines and purines, synthesis of imidazole, pyrazole and oxazole, 3.8. Biologically important heterocycles

Module 4 **Photochemistry and Pericyclic reactions** **15 hrs**

4.1Introduction to Organic photochemistry: 4.2, Photochemical reactions, photo addition, photo oxidation, photo rearrangement, photo dissociation, photo cyclization, 4.3Photochemistry of carbonyl compounds, alkenes and dienes, 4.4. Photochemistry of aromatic compounds, 4.5.Barton and Hoffman - Lofferty reactions, 4.6Applications of photochemistry, 4.7Introduction to Pericyclic reactions and its classification, 4.8Cycloadditions, electrocyclic, sigmatropic, chelotropic and group transfer reactions, 4.9Claisen, Cope and Diels-Alder reactions and their stereochemical aspects, 4.10Dipolar cycloadditions and their utility in organic synthesis, 4.11The ene- reactions, cheletropic reaction and dyotropic reaction, 4.12Applications of pericyclic reactions

References

1. Advanced Organic Chemistry, Part B: Reaction and Synthesis, F.A. Carey and R. S. Sundberg, 5th Edition, Springer (2007)
2. Chemistry of Heterocyclic Compounds, Rakesh Kumar Parashar, and BeenaNegi, Ane Books Pvt Ltd (2016)
3. Chemistry of the Carbonyl Group - A Step-by-Step Approach to Understanding Organic Reaction Mechanisms, Timothy K. Dickens, Stuart Warren, Wiley (2018)
4. Frontier orbital and symmetry controlled pericyclic reactions, Ratan Kumar Kar, Books & Allied Ltd, (2009)
5. Heterocyclic Chemistry at a Glance, John A. Joule, Keith Mills, John Wiley & Sons, Ltd, (2013)
6. Heterocyclic chemistry, J.A. Jouls and K. Mills, 5thedn, Wiley (2010)
7. Heterocyclic Chemistry, Raj K. Bansal, New Age International, (2020)
8. Heterocyclic chemistry, Thomas L. Gilchrist, Pearson Education (2005)
9. March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Michael B. Smith, 7th Edn, Wiley (2006)
10. Microwave Assisted Organic Synthesis, J.P. Tierney and P. Lidstrom, B Lack-Well publishers (2005)
11. Name Reactions: A Collection of Detailed Mechanisms and Synthetic Applications, Jie Jack Li, Fifth Edition, Springer (2014)
12. Organic Chemistry: Theory, Reactivity and Mechanisms in Modern Synthesis, Pierre Vogel and Kendall N. Houk, Wiley –VCH (2019)
13. Organic Name Reactions and Unified Approach, GoutamBrahmachari, Narosa publishers (2008)
14. Organic Photochemistry, J.M Coxon, B Halton, Cambridge University Press (2011)
15. Organic Reactions and their Mechanisms, A. Mohamed Sikkander Noor ShawalNasri, Viva Books (2016)

16. Pericyclic Reactions, G. Gill, Chapman and Hall (1974)
17. Photochemistry and Pericyclic Reactions, Jagdamba Singh, Jaya Singh, New age international (2019)
18. Photochemistry of Organic Compounds: From Concepts to Practice. P. Klán, J. Wirz Wiley, Chichester, (2009)
19. Principles of Organic Chemistry, Norris James F, MJP Publishers (2021)
20. Principles of organic Synthesis, R.O.C Norman, J.M.C. Frsnz, ELBS (1993)
21. Reaction mechanisms in organic synthesis, Parashar, John Wiley and Sons (2008)
22. Reactions Rearrangements And Reagents, S N Sanyal, BharatiBhawan Publishers & Distributors (2019)
23. Textbook of organic name reactions, Kashaw S.K. Atithi books (2015)
24. Textbook of Pericyclic Reactions - Concept and Application, K.C Majumdar, P. Biswas, Medtech publishers (2022)

Teaching Learning Strategies

- Introducing the concept and applications of the subject
- Allowing to study in the depthofthe subject
- Transferring the know-how with suitable
- Providing information about the uses of the titled course to the human

Mode of Transactions

• Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Compare the mechanisms of nucleophilic and electrophilic aliphatic substitution reactions
2. Illustrate the mechanism of Cannizzarro reaction
3. Explain the methods of synthesis of indole. What are its reactions?
4. Explain the applications of photochemistry

DISCIPLINE SPECIFIC COURSE (DSC)

PHYSICAL CHEMISTRY III

Course Title	:	**Physical Chemistry-III**
Course Code	:	**KU05DSCCHE303**
Course Type	:	**DSC**
Course Credits	:	**4**
Pre-requisites	:	**Should have basic idea regarding the terms current, resistance potential and phase.**

Course Objectives:

- To describe the concepts of thermodynamics and their applications
- To know the basic of ions, electrolyte, movement of ions, electrochemistry
- To know how the ionic movements are related to different other fields such as thermodynamics.
- To understand the different phases of matter and their equilibria from which the stability and sustainability can be easily predicted

Credits			TeachingHours			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

Course Outcome:

C 01	Apply the theoretical concepts in applications related to electrochemistry and electromotive force.
C 02	Understand the mechanism of electrical conductance, theories of electrical conductance, and conductometric titration.
C 03	Design different types of electro chemical cell and able to calculate its potential.
C 04	Use scientifically different types of electrodes for pH measurement.
C05	To know about the phase diagrams and study the equilibrium that exists between various states of matter.

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	1	2	2	1	0	0	1	1	1
CO2	3	2	2	1	3	3	1	0	0	1	1	2
CO3	3	2	2	1	2	3	0	1	0	2	2	2
CO4	2	2	2	1	3	3	0	1	0	2	1	2
CO5	2	2	3	1	3	3	0	2	1	2	2	1

Module 1 Electrochemistry **15 hours**

1.1 Specific conductance – molar conductance and equivalent conductance –variation with dilution. - Ohm's law - Conductors - metallic and ionic conductors 1.2 Electrolysis – laws of electrolysis 1.3 Electrolytic conduction - Migration of ions – relative speed of ions – Transport number 1.4 Kohlrausch's law and applications. Conductometrictitrations – 1.5 Electro chemical cell – Daniel cell – Cell reaction – Single electrode potential – statement –explanation of Nernst equation advantages

Module 2Electromotive force **15 hours**

2.1 Equilibrium Electrochemistry: Electrode potential. electrochemical cell, Concentration cell. Thermodynamic properties from EMF data, 2.2 Activity and activity coefficient determination for electrolytes2.3 Ion selective electrodes, Determination of pH, Glass electrode 2.4 Potentiometric titration, Redox indicators, 2.5 Storage cells 2.6 Standard hydrogen electrode – Calomel electrode –measurement of EMF-determination of pH using Hydrogen electrode 2.7 Potentiometric titration.

Module 3 Electrochemistry-III **15 hours**

3.1 Ionic nobilities, influence of pressure and temperature on ion conductance, Walden's equation, abnormal ion conductance.3.2 Derivation of Debye-Huckel-Onsager equation, validity of Debye-Huckel-Onsager equation for aqueous and nonaqueous solution.conductance ratio and Onsager equation, 3.3 dispersion of conductance at high frequencies, Debye-Falken effect. 3.4 Debye-Huckel limiting law (Equation only) and its various forms and qualitative and quantitative tests, osmotic coefficient, ion association and dissociation constant,3.5tripple ion and conductance minima, equilibria in electrolytes. 3.6 Solubility product principle, solubility in presence of common ion, activity coefficient and solubility measurement.

Module 4 :Phase Rule **15 hours**

4.1 Statement of phase rule and explanation of terms (component, degree of freedom, phase)- thermodynamic derivation 4.2 One component system – water system and sulphur system (including meta stable equilibrium) 4.3 Two component systems – reduced phase rule --- simple eutectic systems—lead-silver system --- desilverisation of lead--- KI –water system --- freezing mixtures4.4 Systems involving the formation of compounds with congruent and incongruent melting points—ferric chloride water system and Na_2SO_4 water system- Solid-gas equilibria - decomposition of $CuSO_4.5H_2O$ —deliquescence and efflorescence 4.5 Nernst distribution law-Thermodynamic derivation and derivation from phase rule. Limitations- modifications under special conditions- 4.6 Applications of distribution law to study association and dissociation of salts, solvent extraction, hydrolysis of salts and equilibrium constant of the reaction $KI + I_2 \rightleftharpoons KI_3$.

References

1. Introduction to Electrochemistry, S. Glasstone, D. Van Nostrand.
2. Modern Electrochemistry, J.O.M. Bockris and A.K.N. Reddy, Plenum
3. Physical Chemistry, Daniels and Alberty, John Wiley.
4. The Principles of Electrochemistry, D. A. Mc Innes, Dover Publishers
5. The Principles of Electrochemistry, D.R. Crow, Chapman and Hall
6. Theoretical electrochemistry, L.I. Anthropov, Mir publishers.
7. Thermodynamics for chemists, S. Glasstone, Affiliated East West publication
8. Thermodynamics, Lewis and Randall, McGraw Hill.
9. D. R. Crow, Principles and Applications of Electrochemistry, Blackie Academic and Professional, 4th Edn., 1994.
10. J.O.M. Bokris and A.K.N. Reddy, Modern Electrochemistry, Plenum Press, 1973.
11. Introduction to Electrochemistry, S. Glasstone, D. Van Nostrand.
12. Modern Electrochemistry, J.O.M. Bockris and A.K.N. Reddy, Plenum
13. Physical Chemistry, Daniels and Alberty, John Wiley.
14. An Introduction to chemical thermodynamics, Rastogi and Misra, Vikas publishing.
15. G.W. Castellan, Physical Chemistry, Addison-Lesley Publishing
16. Puri and Sharma , Principles of Physical Chemistry, Vishal Publication Company
17. R.P Rastogi, An Introduction To Chemical Thermodynamics, Vikas Publishing House

Teaching Learning Strategies

- Provide updated Lecture Sessions
- Promote Interactive Sessions including discussions and demonstrations.
- Provide experiments to engage students actively and visual aids like presentations, videos, and models to enhance understanding.
- Encourage students to ask questions during or after the lectures

MODE OF TRANSACTION

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Explain the physical significance of activity.
2. In terms of the Onsagar conductance equation, write down an expression for the conductance ratio. Show that its value decreases with increasing concentration of the solution.
3. Differentiate relaxation effect and electrophoretic effect?

DISCIPLINE SPECIFIC COURSE (DSC)

INORGANIC CHEMISTRY PRACTICAL-II

Course Title	:	**Inorganic Chemistry Practical-II**
Course Code	:	**KU05DSCCHE304**
Course Type	:	**DSC**
Course credit	:	**4**
Prerequisites	:	**General Safe Laboratory practices, Basic inorganic analysis**

Course Objectives:

- The course provides opportunities for hands –on laboratory experiences related to qualitative and quantitative inorganic analysis

Credits			Teaching Hours			Assessment		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
4	0	4	4	0	4	50	50	100

Course Outcomes:

CO1	Perform basic chemical lab procedures by following appropriate lab safety measures & infer the experimental results with mathematical and analytical reasoning.
CO2	Separation and identification of mixture of four cations in a given sample
CO3	Estimation of the content of metal ion present in the whole of the given solution.
CO4	Preparation and characterisation of inorganic complexes
CO5	**Plan** and **Conduct** experiments for identification and characterisation of inorganic compounds.

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3	3	3	2	3
CO2	3	3	3	3	3	3	3	3	3	3	2	3
CO3	3	3	3	3	3	3	3	3	3	3	2	3
CO4	3	3	3	3	3	3	3	3	3	3	2	3
CO5	3	3	3	3	3	3	3	3	3	3	2	3

Module 1 Cation Analysis **30 hours**

Separation and identification of four metal ions of which two are rare/ less familiar cations such as Tl, W, V, Se, Te, Ti, Ce, Th, Zr, U, Mo, and Li (interfering acid radicals not present). Confirmation by spot test. [**Minimum 10 mixtures are to be recorded**]

Module 2 Volumetric estimation **30 hours**

a) EDTA - Al, Ca, Cu. Ni, Co, Hardness of water

b) Cerimetry - Fe(II), nitrate

c) Estimation of Dissolved Oxygen by Winkler's method

[**A minimum of 5 experiments to be recorded**]

Module 3 Preparation **30 hours**

Preparation of the metal complexes, checking metal content and their physicochemical characterization using spectroscopic (UV-Visible, IR) studies / thermal (TG , DTA), Magnetic susceptibility studies / XRD data:

Nickel(dimethyl glyoxime), Potassium trioxalatochromate(III), Tetraammoniumcopper(II) sulphate and Hexaamminecobalt(III) chloride, and Potassium hexathiocyanatochromate(III).

[**A minimum of 5 experiments to be recorded**]

Module 4 **30 hours**

1. Quantitative separation of binary mixtures and estimation of components by volumetric, gravimetric, colorimetric, and electroanalytical methods: Cu(lI), Ni(II), Fe(III), Mg(lI). Al(III), Ca(II), Ba(II) and Zn(II).

2) Analysis of ores

   a) Analysis of brass

   b) Analysis of solder

3) Synthesis of any two of the following metal oxide nanomaterials and their characterization using X-ray, microscopic or spectrochemical methods.

- ZnO / TiO_2/ Co_3O_4/ $Co(OH)_2$ / NiO / FeO etc. (Any two)

[**A minimum of 10 experiments to be recorded**]

Reference

l) G H Jeffery, J Bassett, J Mendham, R. C. Denney, Vogel's Textbook of Quantitative Chemical Analysis, 5thEdn, Longman,1989.

2) A. I. Vogel, G. Svehla: Vogel's Qualitative Inorganic Analysis, 7thEdn, Longman,1996.

3) J. Derek Woollins, Inorganic Experiments,3rd edn.,, Wiley-VCH,2009

4) D.M Adams, J.B. Raynor, Advanced Practical Inorganic Chemistry; Wiley,1965

5) W L Jolly, Preparative Inorganic Reactions, Interscience publishers. New York, 1964.

6) D. A. Skoog and D. M. West, Analytical Chemistry: An Introduction, Saunders College Publishing, 4th edition, 1986.

7) W. G. Palmer, Experimenral Inorganic Chemistry, Cambridge University Press, 1954.

8) T. Pradeep, Textbook of Nanoscience and Nanotechnology, McGraw Hill India, 2012

9) Robert Vajtai, Springer Handbook of Nanomaterials (Springer Handbooks), Springer, 2013.

10) V. Ramanujam, Inorganic Semi micro Qualitative analysis, 3rd edition, Thc National Publishing House, Chennai, 1974.

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills

- Promoting Active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminars	10	
	Viva	10	

Sample Questions to test Outcomes:

1. Separate and identify four metal ions of which two are rare/ less familiar cations such as Tl, W, V, Se, Te, Ti, Ce, Th, Zr, U, Mo, and Li.
2. Estimate the amount of metal ion present in the whole of the given solution using complexometry.
3. Prepare Nickel(dimethyl glyoxime)according to given procedure.
4. Estimate the amount of metal ions present in the whole of the given binary mixture.

DISCIPLINE SPECIFIC ELECTIVE (DSE)
POLYMER CHEMISTRY

Course Title	:	**POLYMER CHEMISTRY**
Course Code	:	**KU05DSCCHE304**
Course Type	:	**DSC**
Course credit	:	**4**
Prerequisites	:	**Knowledge about monomers, fundamentals of polymer chemistry**

Course Objectives:

- To learn the about various polymers and its reactions
- To study the polymerization techniques
- To describe the polymer structure
- To understand the types polyemerization methods

Course Outcomes

CO1	Describe the background of polymer chemistry
CO2	Illustrate various properties of polymers
CO3	Study the general synthetic methods of various of polymers
CO4	To study the specific synthesis of popular polymers

Mapping of Course Outcome to POs/PSOs

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	1	1	2	2	1	1	2	2	3	1	2	1
CO2	1	2	3	3	2	1	2	3	1	3	1	1
CO3	1	2	3	2	3	1	3	2	2	2	3	1
CO4	1	2	3	1	3	2	3	1	3	2	1	2

MODULE 1 **15 hours**

Polymer Nomenclature - Classification Of Polymers - Natural And Synthetic Polymers - Organic And Inorganic Polymer - Linear, Branched And Cross Linked Polymers - Thermoplastic And Thermosetting Plastics – Elastomers And Fibres – Homopolymer And Copolymer - Synthetic Routes And Applications Of Polymer.

MODULE 2 **15 hours**

Properties Of Polymers – Average Molecular Weight- Number Average, Weight Average, Sedimentation Average And Viscosity Average Molecular Weight- Polydispersity and Polydispersity Index – Degree Of Polymerization.

Glass Transition Temperature - Defintion And Importance Of Glass Transition Temperature, Factors Affecting Glass Transition Temperature.

MODULE 3 **15 hours**

Polymerization Techniques – Addition Polymerization – Free Radical Polymerization; Initiation, Propagation and termination- Coordination Polymerization; Mechanism And Advantage of Ziegler Natta catalysis - Ionic Polymerization - Condensation Polymerizsation.

MODULE 4 **15 hours**

Synthesis and applications of polyethylene, polypropylene, PVC, polystyrene, polyurethane, phenolic and epoxy resin – synthetic rubber – Buna-S, Buna-N, Neoprene and butyl rubber – Biodegradability of polymers.

REFERENCE

1. A textbook of Polymer Chemistry – F.W. Billmeyer.
2. Polymer Chemistry – V.R Gowarikar.
3. Polymer Chemistry – B.K Sharma.
4. Principles of Polymer Chemistry – P.J Flory
5. Polymer Chemistry – Raymon b sepmour

Teaching Learning Strategies

- Provide updated Lecture Sessions
- Promote Interactive Sessions including discussions and demonstrations.
- Provide experiments to engage students actively and visual aids like presentations, videos, and models to enhance understanding.
- Encourage students to ask questions during or after the lectures

MODE OF TRANSACTION

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. What are the classifications of polymers
2. What are copolymers
3. Compare the contrast between addition polymerizationa and condensation

   polymerization.
4. Discuss various aspects of free radical polymerization.

Teaching Learning Strategies

- Provide updated Lecture Sessions
- Promote Interactive Sessions including discussions and demonstrations.
- Provide experiments to engage students actively and visual aids like presentations, videos, and models to enhance understanding.
- Encourage students to ask questions during or after the lectures

MODE OF TRANSACTION

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

4. Explain the physical significance of activity.
5. In terms of the Onsagar conductance equation, write down an expression for the conductance ratio. Show that its value decreases with increasing concentration of the solution.
6. Differentiate relaxation effect and electrophoretic effect?
7. Discuss the phase rule and its significance

DISCIPLINE SPECIFIC ELECTIVE (DSE)

MEDICINAL CHEMISTRY

Course Title	:	**MEDICINAL CHEMISTRY**
Course Code	:	**KU05DSECHE306**
Course Type	:	**DSE**
Course credit	:	**4**
Prerequisites	:	**Organic chemistry, biological systems, biological action, drugs and action of drugs**

Course Objectives:

- To provide an idea about the history, development and importance of medicinal chemistry
- To provide a description of the principle of drug action and its chemistry
- To illustrate the methods of synthesis of various important drugs
- To provide the details and actions of different types of drugs.

Course Outcomes

CO1	Learn the history and development of medicinal chemistry and its importances
CO2	Acquire knowledge about the drug action and its mechanism
CO3	Analyse the method of synthesis and purification of drugs
CO4	Illustrate the chemistry and action of various drugs

Mapping of Course Outcome to POs/PSOs

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**
CO 1	3	3	3	3	2	3	3	2	2	2	1	1
CO 2	3	3	2	2	2	3	2	1	2	2	1	1
CO 3	2	3	3	2	2	1	1	2	2	2	2	1
CO4	1	3	3	1	1	3	2	3	2	2	1	1

Module 1 **The Drug chemistry** **15 hrs**

1.1History and development of medicinal chemistry1.2Importance of chemistry in pharmacy and molecular pharmacology1.3Physicochemical properties in relation to biological action, ionization, solubility, partition coefficient, protein binding, chelation and bioisosterism1.4Different classes of drugs1.5Introduction to herbal medicine1.6Introduction to the chemistry of antibiotics1.7Introduction the chemistry of homeopathy1.8Introduction to nanomedicine1.9Physico-chemical properties of organic medicinal agents1.10Chemistry of prodrugs

Module 2 **The Drug metabolism** **15 hrs**

2.1General principle of drug action: Phase I and Phase II, 2.2Factors affecting drug metabolism including stereo chemical aspects, 2.3Drugs acting on autonomic nervous system, 2.4Chemistry of sedatives and hypnotic drugs Introduction to psycho active drugs and drug action, 2.5Drug delivery systems, 2.6Enzyme inhibitors in medicine2.7Pharacokinetics, drug absorption, distribution2.8Drugs acting on Central Nervous System2.9Drug receptors and drug receptor interactions2.10Structure activity relationships (SAR and QSAR) and mechanism of drug action2.11Non specific action of drugs. Toxicology

Module 3 **The Drug synthesis** **15 hrs**

3.1Drug discovery and design, 3.2Hansch analysis, Craig plot and Free Wilson analysis

3.3 Biosynthesis and catabolism of catecholamine and acetylcholine3.4Various approaches used in drug design, 3.5, Hammet's electronic parameter, Tafts steric parameter and Hansch analysis, 3.6. Methods of purification, 3.7Concept and applications of combinatorial chemistry, 3.8.Solid phase and solution phase synthesis, 3.9. Spectroscopic characterizations, 3.10.Pharmacophore modelling and docking techniques

Module 4 **Specialty Drugs** **15 hrs**

4.1Synthesis and action of penicillin, 4.2Chemistry of synthesis of ibuprofen and Paracetamol, 4.3Chemistry of synthesis of Epinephrine and Phenylephrine, 4.4Chemistry of synthesis of Dopamine Methyldopa abd Clonidine, 4.5. Chemistry of synthesis of Dobutamine, Isoproterenol and Terbutaline, 4.6Chemistry of synthesis of Salbutamol, Bitolterol and Naphazoline, 4.7.Chemistry of synthesis of Oxymetazoline and Xylometazoline, 4.8.Examples of Alpha and Beta adrenergic blockers, 4.9.Antipsychotics and Anticonvulsants, 4.10.Drugs acting on Central Nervous System, 4.11.General anaesthetics, 4.12.Narcotic and non-narcotic analgesics

Reference:

1. Active Pharmaceutical Ingredients: Development, Manufacturing, and Regulation, Stanley Nusim, 2nd Edn, Taylor & Francis (2010)
2. Fundamentals of Medicinal Chemistry, Gareth Thomas, Wiley (2004)

3. Introduction to Medicinal Chemistry, G.L. Patrick, Oxford University Press (2023)
4. An Introduction to Medicinal Chemistry, Patrick,Graham, Oxford; Fifth edition (2013)
5. Medicinal chemistry, D. Sriram,Yogeeswari.P, 2nd edition, Pearson (2010)
6. Medicinal Chemistry, AshuthoshKar, New Age International (2018)
7. Medicinal Chemistry, An introduction, G. Thomas, 2ndEdn, Wiley (2007)
8. Medicinal Chemistry, D.Sriram, P. Yogeeswari, 2ndEdn, Pearson Education (2010)
9. Pharmaceutical Organic Chemistry, Bhasin, S. K, Reena Gupta, Elsevier (2012)
10. Pharmacology and Pharmacotherapeutics, SataskarR.S.Bhandakan, S.D. and Ainapure S.S., Popular Prakashan (2017)
11. Principals of Organic Medicinal Chemistry, R.R. Nadendla, New Age International (2005)
12. Rang and Dale's Pharmacology, Rang H. P., Dale M. M., Ritter J. M., Flower R. J.Churchill Livingstone, Elsevier (2015)
13. Foye's principles of medicinal chemistry, Foye, William O., Lemke Thomas L., Williams David A. Philadelphia : Wolters Kluwer Health/Lippincott Williams & Wilkins (2013)
14. The Practice of Medicinal Chemistry, Wermuth, C. G., editor, Raboisson, Pierre, (2015)
15. Burger's Medicinal chemistry, drug discovery and development,Abraham, Donald J. Wiley, (2010)

Teaching Learning Strategies

- Introducing the concept of the subject
- Providing knowledge about the subject
- Transferring the know-how with examples
- Illustrating the application of the titled course to the society

Mode of Transactions

• Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50

Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Describe the chemistry of antibiotics
2. Explain the mechanism of drug action
3. Discuss the applications of combinatorial chemistry
4. Explain the synthesis of Paracetamol.

SEMESTER VI

DISCIPLINE SPECIFIC COURSE (DSC)

ORGANOMETALLIC COMPOUNDS

Course Title	**:**	**ORGANOMETALLIC COMPOUNDS**
Course Code	**:**	**KU06DSCCHE307**
Course Type	**:**	**DSC**
Course credit	**:**	**4**

Prerequisites : **Basics of Organometallic Chemistry, Nature of metal ligand bonds, V.B theory of Metal Complexes**

Course Objectives:

- To provide an idea about the history, development and Organometallic Chemistry
- To provide a description of the structure of organometallic compounds
- To illustrate the methods of synthesis and reactions of various organometallic compounds
- To provide the details and actions of different catalysts.

Course Outcomes

CO1	Learn the history and development of Organometallic chemistry
CO2	Acquire knowledge about the structure and bonding of organometallic compounds
CO3	Analyse of possible organometallic reactions
CO4	Deducing and applying organometallic reactions in various catalytic cyles

Mapping of Course Outcome to POs/PSOs

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**
CO 1	3	3	3	3	2	3	3	2	2	2	1	1
CO 2	3	3	2	2	2	3	2	1	2	2	1	1
CO 3	2	3	3	2	2	1	1	2	2	2	2	1
CO4	1	3	3	1	1	3	2	3	2	2	1	1

Module 1. Introduction **15 hours**

Introduction. Classification based on the nature of metal-carbon bond. Hapticity in Organometallic compounds, 18- electron rule, numerical problems, and stability, Application of 18 electron rule to predict M-M bond. Factors favouring the formation of metal-metal bonds, preparation, properties, structure and uses of mononuclear (Ni,Fe), binuclear (Fe,Mn,Co) and trinuclear (Fe) metalcarbonyls - Preparation, properties, structure andbonding of Ferrocene. aromaticity and reactions (acetylation, alkylation). Metal-alkene complexes- – Preparation and structure of Zeise's salt

Module 2 Structure and Bonding **15 hours**

Organometallic Compounds-Synthesis, Structure and Bonding, Ligands and their bonding with metals: CO, CN, NO, N_2, H_2, alkene, alkyne, PR_3, arenes, dienes, allyl, carbenes – carbynes (Fischer and Schrock), Preparation of metal nitrosyl, dinitrogen, alkyl, aryl, alkene, alkyne, carbenes –carbynes, arene and phosphine complexes, 18 electron rule, Bridging and non-bridging (Polynuclear) metal carbonyls, Wade-Mingos rules. Cyclopentadienyl complexes – fluxionality.

Module 3 Reactions **15 hours**

Reactions of Organometallic Compounds and Catalysis- Unique reactions in organometallic chemistry: Oxidative addition (concerted and step-wise, Caryl-H activation – orthometallation), reductive elimination, migratory insertion (1,1 and 1,2), β-hydride abstraction/elimination. Agostic interactions, σ-bond metathesis Zr(IV) and Lu(III), Preparation and structure of mononuclear carbonyls- $Mo(CO)_6$, $Fe(CO)_5$ and $Ni(CO)_4$, Polynuclear carbonyls, bridged carbonyls, and bonding in metal carbonyls – $Mn_2(CO)_{10}$ and $Fe_2(CO)_9$. Synergic effect and use of IR data in metal carbonyls to explain extent of back bonding.

Module 4 Catalysis **15 hours**

Catalytic properties of organometallic compounds-Homogeneous/Heterogeneous catalysis: Tolman catalytic loops, Hydrogenation by Wilkinson Catalyst, Olefin isomerization, Wacker process, Hydroformylation (Co & Rh), Monsanto & Cativa acetic acid process, Ziegler-Natta Polymerization including metallocene based Zr catalyst, Water gas shift reaction, the Fischer-Tropsch reaction (synthesis of gasoline) Grubbs (I generation & II Generation) and Schrock catalysts – Preparation and characteristics, Olefin metathesis.

References

1. F.A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 6th Edition, Wiley India Pvt.Ltd., New Delhi, 2009 (Reprint).
2. J.E. Huheey, E.A. Keitler and R.L. Keitler, Inorganic Chemistry–Principles of Structure and Reactivity, 4th Edition, Pearson Education, New Delhi, 2013.
3. D.F. Shriver and P. Atkins, Inorganic Chemistry, 5th Edition, Oxford University Press, NewYork, 2010.

4. J.D. Lee, Concise Inorganic Chemistry, 5th Edition, Oxford University Press, New Delhi 2008.
5. B. D. Guptha, A. J. Elias Baisc Organometallic Chemistry, Concepts , Synthesis and Applications, 2nd Edition, University Press, 2010
6. K.F. Purcell, J.C. Kotz, Inorganic Chemistry, Holt-Saunders, 1977.
7. F. Basolo, R.G. Pearson, Mechanisms of Inorganic Reaction, John Wiley & Sons, 2006.
8. P. Powell, Principles of Organometallic Chemistry, 2ndEdn., Chapman and Hall, 1988.
9. Robert H. Crabtree, The Organometallic Chemistry of the Transition Metals, 4thEdn., Wiley Interscience, 2005.
10. Sumit Bhaduri, Doble Mukesh, Homogeneous Catalysis: Mechanism and Industrial Applications, Wiley Interscience, 2000.
11. Astruc, D.; Organometallic Chemistry and Catalysis, Springer Verlag, 2007.
12 Organometallic Chemistry,R C Mahraotra, A Singh, New age international

Teaching Learning Strategies

- Introducing the concept of the subject
- Providing knowledge about the subject
- Transferring the know-how with examples
- Illustrating the application of the titled course to the society

Mode of Transactions

• Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	

	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

5. Describe the chemistry of antibiotics
6. Explain the mechanism of drug action
7. Discuss the applications of combinatorial chemistry
8. Explain the synthesis of Paracetamol.

DISCIPLINE SPECIFIC COURSE (DSC)

THEORETICAL CHEMISTRY –I

Course Title	**:**	**THEORETICAL CHEMISTRY-1**
Course Code	**:**	**KU06DSCCHE308**
Course Type	**:**	**DSC**
Course credit	**:**	**4**
Prerequisites	**:**	**Brief history of quantum mechanics and fundamentals of classical mechanics, Mathematical knowledge of Differentiations and integrals**

Course Objectives:

- To provide an idea about the history and development of quantum mechanics
- To provide the mathematical techniques of quantum chemistry
- To illustrate the methods of applications of quantum mechanics to simple systems
- To illustrate the methods of applications of quantum mechanics to chemical systems

Course Outcomes

CO1	Learn the history and development of Quantum chemistry
CO2	Acquire knowledge about the nuances of particle in box problem
CO3	Application of quantum mechanics to harmonic oscilator

CO4	Deducing and applying quantum mechanics to rigid rotor.

Mapping of Course Outcome to POs/PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	3	3	3	2	3	3	2	2	2	1	1
CO 2	3	3	2	2	2	3	2	1	2	2	1	1
CO 3	2	3	3	2	2	1	1	2	2	2	2	1
CO4	1	3	3	1	1	3	2	3	2	2	1	1

Unit-I Brief History and Formulation of Quantum Mechanics 15 Hours

Origin of quantum mechanics, Explanation of photo electric effect, Electron-diffraction experiments and wave nature of electrons, de Broglie matter waves, Heisenberg's uncertainty principle, Deduction of Schrödinger equation from classical wave equation Postulates of Quantum Mechanics: Wave function (Ψ) and the physical significance of Ψ^2, Rules of proper behavior, Normalization of wavefunction and its physical significance, Quantum mechanical operators, their derivation, and properties, Hermitian operators, Commutation of operators and its physical significance, Eigen function and Eigen value, Expectation value, Time-independent and time-dependent Schrödinger Equations, Method of separation of variables.

Unit-II Particle in Box Particle in a box Problem 15 Hours

Free particle, The particle in a one-dimensional box, Extension of this model into two- and three- dimensional boxes; Application of Method of separation of variables to solve the problems of multi-dimensional boxes, Degeneracy, Symmetry breaking, Treatment of more than one particle (non-interacting) in a box. Applications.Finite-barrier model and the concept of quantum mechanical tunnelling.

Unit –III Harmonic Oscillator 15 Hours

Harmonic Oscillator: Quantum mechanical model for molecular vibrations, Derivation of Schrödinger equation. Wave functions and energies, Hermite equation and Hermite

Polynomials, Recursion formula, Application to vibrational spectroscopy.Anharmonic oscillator and its significance in vibrational spectroscopy.

Unit –IV Rigid Rotor **15 Hours**

Rigid Rotor: Quantum mechanical model for rotational motion. Planar rigid rotator (Particle on a ring), The wave equation in spherical polar coordinates, The Φ-equation and its solution, Nonplanar rigid rotator (particle on a sphere), Separation of the Schrödinger equation into Φ-equation Θ-equation and their solutions, Legendre and Associated Legendre equations, Legendre and Associated Legendre polynomials, Spherical harmonics (Y), Polar plots of Y, Angular momentum operators L and L^2. Quantization of angular momentum, L_x, L_y, and L_z and L^2. Commutation relationships of various angular momentum operators and their physical significance.The concept of space quantization of angular momenta.

References

1. Introduction to Quantum Mechanics, L. Pauling and W.B. Wilson, McGraw Hill
2. D. A. McQuarrie, Quantum Chemistry, 3rd ed., Univ. Sci. Books, Mill Valley, California, 1983.
3. I. N. Levine, Quantum Chemistry, 6th ed., Pearson Education, London, 2008.
4. P. W. Atkins, R.S Friedman, Molecular Quantum Mechanics, 5th ed., OUP, Oxford, 2012.
5. J. P. Lowe, Quantum Chemistry 3rd ed., Academic Press, New York, 2008.
6. A. Szabo, N. S. Ostlund, Modern Quantum Chemistry: Introduction to Advanced Electronic Structure Theory, Dover Book ed., Mc.Graw-Hill, New York, 1982.
7. P.W. Atkins, Physical Chemistry, 8th ed., Wiley, New York, 2006.
8. R. K. Prasad, Quantum Chemistry, 3rd ed., New Age International, 2006.
9. D. J. Griffiths, Introduction to Quantum Mechanics, 2nd ed., 2004.
10. J. J. Sakurai, Modern Quantum Mechanics, 2nd ed., 2010.

Teaching Learning Strategies

- Introducing the concept of the subject
- Providing knowledge about the subject
- Transferring the know-how with examples
- Illustrating the application of the titled course to the society

Mode of Transactions

• Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Describe the photoelectric effect
2. Explain Heisenberg Uncertainty principle
3. What are Hermite Polynomials
4. How to convert associated Legendre equation to Legendre equation.

DISCIPLINE SPECIFIC CORE (DSC)

PHYSICAL CHEMISTRY PRACTICAL-II

Course Title	:	**Physical Chemistry Practical- II**
Course Code	:	**KU06DSCCHE309**
Course Type	:	**DSC**
Course Credits	:	**4**
Pre-requisites	:	**Basic analytical techniques**

Course Objectives:

- To impart practical knowledge of spectrochemical and electrochemical techniques of different systems.
- To understand the various analytical methods of analysis of components in solution.
- To study the adsorption rates of various systems by using adsorption isotherm.
- To explore the chemistry of the three phases (solid, liquid, and gases) of material and kinetic aspects of chemical reactions.

Credit			Teaching Hours			Assessment		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
0	4	4	0	4	4	50	50	100

Course outcomes:

C01	Evaluate the partition coefficient of a compound between two immiscible solvents
C02	Construct a phase diagram of a binary and ternary system
C03	Perform electrochemical and spectrochemical studies for the quantitative and qualitative determination of components in the solutions.
C04	Determine the molecular weight of solute by different methods and adsorption rates of various systems.
C05	Analyze the rate of the different chemical reactions and determine the reaction's order.

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	2	3	3	2	2	2	3	1	3
CO2	3	3	3	2	3	3	2	2	2	3	1	3
CO3	3	3	3	2	3	3	2	2	2	3	1	3
CO4	3	3	3	2	3	3	2	2	2	3	1	3
CO5	3	3	3	2	3	3	2	2	2	3	1	3

Module I Distribution Methods& Kinetics 30 hours

1.1 Distribution law: Determine the partition coefficient of the distribution of succinic acid between water and l-butanol, 1.2 Determination of partition coefficient of benzoic acid between toluene and water, 1.3Determination of partition coefficient of partition of iodine between water and carbon tetrachloride, 1.4 Study the kinetics of the acid-catalyzed hydrolysis of ethyl acetate and evaluate the value of the rate constant. 1.5 Evaluate the activation energy of the acid-catalyzed hydrolysis of methyl acetate

Module II Phase Equilibria Studies& Adsorption 30 hours

2.1Construction of the phase diagram of simple eutectics-determination of the composition of unknown mixtures,2.2 Partially miscible liquids: Critical solution temperature, determination of the composition of unknown mixtures, 2.4Completely miscible liquid systems: 2.7 Construction of phase diagrams of two-component liquid systems, 2.8 Three component systems: With one pair of partially miscible liquids, construction of phase diagrams and tie lines,2.9 Study the adsorption of acetic acid and oxalic acid by activated charcoal and verily the Langmuir and Freundlich adsorption isotherms.

Module III Molecular weight determination &Optical measurements 30 hours

3.1Molecular Weight Determination- Rast and transition temperature method, 3.2 molecular weight of a solid using a solid solvent by cooling curve method, 3.3 Molecular weight determination by study of depression in transition temperature, 3.5 Refractometry: Determination of molar refractions of pure liquids, determination of the composition of mixtures. 3.6 Polarimetry: Determination ofthe optical rotation and specific rotation of the given optically active substance, 3.7 Determination ofthe concentration ofthe unknown solution of the optically active compound, 3.8 Kinetics of inversion of cane sugar by optical rotation measurement.

Module IV Electrochemical &Spectrochemical Studies 30 hours

4.1 Potentiometry: Electrode potentials of Zn and Ag electrodes, determination of standard potentials, determination of mean activity co-efficient of an electrolyte at different molalities by EMF method, dissociation constant measurement, determination of strength of a given solution, 4.2 Potentiometric titration, 4.3 Flame photometry: quantitative determination of Na+ , K+ , Li+ and Ca^{2+} ions, 4.4Polarography: determination of number of components and concentration (Cd^{2+}, Zn^{2+},Pb^{2+} , Cu2+, etc.), 4.5 Conductometric titration, determination of unknown concentration.4.6 UV-Vis. Spectrophotometer: Absorbance and determination of the order of a reaction.4.7 Colorimetry: quantitative determination of the components of a binary mixture,4.8 Computer applications in chemistry a) Chem draw/ ISIS sketches for reaction and mechanism (minimum 3 Nos) b) C++ programming for the calculation of thermodynamic parameters.

References

1. A Text Book of Quantitative Inorganic Analysis, A.I. Vogel, Pearson Education
2. Experimental Inorganic Chemistry, W.G. Palmer, Cambridge University Press.
3. Experimental Physical Chemistry, D.P. Shoemaker and C.W. Garland, McGraw-Hill.
4. Experimental Physical Chemistry, F. Daniels and J.H. Mathews, Longman.
5. Experimental Physical Chemistry, V.d.Ahuwale and parul, New age International.
6. Instrumental Methods of Analysis, H.H. Willard, L.L. Merritt and J.A. Dean, AEWt Press.
7. Practical Physical Chemistry A M James, J A Churchil
8. Practical Physical Chemistry, A. Finlay and J. Akitchener, Longman
9. Practical Physical Chemistry, D.M. James and F.E. Prichard, Longman

Teaching Learning Strategies

- Provide experiments to engage students actively and visual aids like presentations, videos, and models to enhance understanding.
- Encourage students to ask questions during or after the practical.
- Allow students to conduct experiments under supervision.
- Provide students with the required safety instructions and guidelines for lab work

Mode of transaction

- Discussions and demonstrations.

ASSESSMENT RUBRICS			Total
End Semester Evaluation	External Exam	50	50
Continuous Evaluation	Internal Exam	40	50
	Viva	10	

Sample Questions to test Outcomes.

1. How to determine distribution coefficient of succinic acid in water and butanol?
2. How to determine concentration of given hydrochloric acid solution conductometrically?

DISCIPLINE SPECIFIC ELECTIVE (DSE)

ENVIRONMENTAL CHEMISTRY

Course Title	**:**	**ENVIRONMENTAL CHEMISTRY**
Course Code	**:**	**KU06DSECHE310**
Course Type	**:**	**DSE**
Course Credits	**:**	**4**
Pre-requisites	**:**	**Basics concepts in environmental science, Fundamentals of analytical and instrumentation techniques**

Course Objectives

1. To impart awareness on public health, waste management and pollution
2. To introduce various environmental policies laws and regulations that are relevant to environmental protection
3. To understand the interconnections between different sectors of the environment (soil, water, atmosphere) and the effect of human activities on these causing pollution and other impacts
4. To apply the knowledge on analytical chemistry to environmental processes and samples

Credit			Teaching Hours			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	60	0	60	50	50	100

Course Outcome

CO1	Acquire theoretical knowledge and understanding of fundamental concepts of environmental technology
CO2	Understand the impact of human and natural impacts on atmosphere and ecosystem
CO3	To understand the type and sources of air, water and soil pollution
CO4	To acquire knowledge on air, water and soil pollution control measures
CO5	Acquire knowledge about advanced instrumentation facilities used for environmental chemical analysis

Mapping of course Outcomes with POs/PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8

CO 1	**3**				**3**	**3**	**2**	**2**	**2**	**3**	**1**	**2**
CO 2	**3**				**3**	**3**	**2**	**2**	**2**	**3**	**1**	**2**
CO 3	**3**				**3**	**3**	**2**	**2**	**2**	**3**	**1**	**2**
CO 4	**3**				**3**	**3**	**2**	**2**	**2**	**3**	**1**	**2**
CO 5	**3**				**3**	**3**	**2**	**2**	**2**	**3**	**1**	**2**

3 - Well correlated, 2 - Not well correlated but it has agreeable correlation, 1 - No correlation

Course Contents

Module I: Introduction to Environmental Chemistry **15hrs**

1.1 Definition, scope and importance of environmental science, 1.2 Components of environment: atmosphere, hydrosphere, lithosphere and biosphere, 1.3 Fundamentals of ecology and ecosystem, 1.4 Natural resources, 1.5 Effects of human activities on environment: agriculture, housing, industry, mining and transportation activities, 1.6 Environmental impact assessment, 1.7 Environmental policies, 1.8 Environmental law and regulations.

Module II: Environmental Pollution **15hrs**

2.1 Types of air pollutants: primary and secondary air pollutants, Gaseous, solid and bio pollutants, 2.2 Acid rain and its ecological effects, 2.3 ozone depletion, 2.4 Greenhouse effect and global warming, 2.5 Thermal pollutionimpacts of air pollution on human being, plants, materials, buildings and climate, 2.6 Control measures of air pollution, 2.7 Sources of noise pollution - Indoor and outdoor noise pollution, 2.8 Impact of noise pollution on plants and animals. 2.9 control measures of noise pollution.

Module III: Water and Soil Pollution **15hrs**

3.1 Water pollution: soluble metals, soaps and detergents, insecticides and pesticides, 3.2 Control of water pollution., 3.3 Sources of soil pollution, 3.4 Soil pollution: ground water, heavy metal poisoning, 3.5 Industrial pollution, agriculture pollution, 3.6 Radiation and radioactive pollution. 3.7 Marine and coastal pollution, 3.8 Sources of marine pollution, control measures, 3.9 Pollution status of coastal and ocean waters.

Module IV: Environmental Chemical Analysis **15 hrs**

4.1 Instrumental methods used for the analysis of atmospheric aerosols, sound pollution and radioactive pollution. 4.2 Analysis of drinking water for total oxygen content, turbidity, and organics. 4.3 Chromatography technique is used for the detection of organic compounds, 4.4 Instrumental methods in environmental chemical analysis - chemiluminescence spectroscopy, FT-IR spectroscopy, atomic absorption spectroscopy.

References

1. Environmental Chemistry a global perspective, G.W. vanLoon and S.J. Duffy, Oxford University Press.
2. Environmental chemistry, A.K. Bhagi and G.R. Chatwal, Himalaya Publishing House
3. Environmental Chemistry, Ian Williams, John Wiley & Sons
4. Environmental chemistry, Peter O'Neill, Blackie Academics
5. Fundamental concepts of Environmental chemistry G.S. Sodhi, Narosa publications
6. C. Baird, Environmental Chemistry, W. H. Freeman and Company, 1998.
7. D. W. Hawker, D. W. Conell, M. Warne, P. D. Vowles: Basic Concepts of Environmental Chemistry, Lewis Publishers, Inc..1997.

Teaching Learning Strategies

- Provide updated Lecture Sessions
- Promote Interactive Sessions including discussions and demonstrations.
- Provide experiments to engage students actively and visual aids like presentations, videos, and models to enhance understanding.
- Encourage students to ask questions during or after the lectures

Mode of Transaction

- Lectures, seminars, discussions, and demonstrations

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1 Explain the various types of spectroscopic techniques used for environmental analysis

2 Explain the chemistry of chlorofluorocarbons in depleting the ozone layer.

3 Discuss the major objectives of environmental pollution monitoring.
4 Discuss your views on the global perspective of Environmental pollution.
5 Write a short note on adverse effects of acid rain.

DISCIPLINE SPECIFIC ELECTIVE (DSE)

NANOMEDICINE AND DRUG DELIVERY

Course Title	:	**Nanomedicine and Drug delivery**
Course Code	:	**KU06DSECHE311**
Course Type	:	**DSE**
Course Credits	:	**4**
Pre-requisites	:	**Basic awareness on Biochemistry and properties of nanomaterials**

Course Objectives:

- To get an overview of the exciting and emerging discipline of nanomedicine.
- To understand the specific aspects of nanomaterials as applied to biology and medicine
- To learn about the essential role of nanosensors in medical field.
- To understand the role of controlled, and targeted delivery systems for drugs and genetic materials using polymeric systems, colloidal drug delivery systems.

Credits			TeachingHours			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

Course Outcome:

C 01	Summarise the background and history of Nanomedicine
C 02	Examine the role of nanosensors in medical field
C 03	Apply the principles and technology in the design of controlled release drugdelivery systems.
C 04	List the criteria for selection of a drugs and nanocarriers for the development ofnovel drug delivery systems
C 05	Interpret the formulation of novel nanoparticles-based drug delivery systems

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	2	3	3	2	1	1	2	1	1
CO2	3	2	2	2	3	2	1	1	1	3	2	1
CO3	3	3	3	1	3	3	2	1	1	3	1	1
CO4	3	3	3	2	3	3	1	2	1	2	2	2

Module 1 Essential molecular biology and the idea of Nano-Medicine: 15 hours

1.1 Molecular Cell Biology: Cell- Structure & Function of Cell Membrane, Different cell types and their Functions, Sub-cellular Organelles and their Functions, Nucleotide- Structure and Functions of DNA & RNA. Biologically important nucleotide, protein synthesis, unnatural amino acid, 1.2 Mechanistic understanding of various diseases and target identification for early detection 1.3 History of the nanomedicine – The Biological and Mechanical Traditions – Nano-medicine – 1.4 Taxonomy – Bio-Pharmaceuticals – 1.5 Implantable Materials – Implantable Devices – 1.6 Surgical Aids – 1.7 Diagnostic Tools – Genetic Testing – Imaging – Nanoparticles Probe – 1.8 Case Analysis – 1) Respirocytes – Mechanical Artificial Red Cells – 2) Using DNA as a construction medium.

Module 2 Fundamentals of Nano pharmaceuticals 15 hours

2.1 Nano pharmaceuticals in clinical translatability, 2.2 Target Identification and Drug designing: High-Throughput Screenings, 2.3 Affinity matrix approaches: On-bead affinity matrix, Biotin tags in affinity matrix, Fluorescent tags in affinity matrix, Photo-affinity tags in affinity matrix, 2.4 Drug western approaches, 2.5 Three-hybrid system approaches: mRNA display approaches, Protein micro-array approaches, Drug affinity responsive target stability

Module 3. Drug delivery basics 15 hours

3.1 Needs and Requirements – 3.2 Nanoparticle Flow: Implications for Drug Delivery – 3.3 Polymeric Nanoparticles as Drug Carriers and Controlled Release Implant Devices – 3.4 Genetic Vaccines 3.5 A Role for Liposomes – 3.6 Polymer Micelles as Drug Carriers 3.7 Recent Advances in Microemulsions as Drug Delivery Vehicles – 3.8 Lipoproteins as

Pharmaceutical Carriers – Solid Lipid Nanoparticles as Drug Carriers, 3.9 Multi-targeted drugs – delivery of nucleic acids- barriers to therapeutic applications –3.10 interaction of organic molecules of the drug with pathological tissue, 3.11 Ligand targeted nanoparticles drug delivery: combining multiple functions - formation of nucleic acid core particle – protective steric coating

Module 4. Nanocapsules 15 hours

4.1 Nanocapsules – A New Drug Delivery System Nanocapsules preparation, 4.2 Characterization and Therapeutic Applications 4.3 Dendrimers as Nanoparticulate Drug Carriers – Cells and Cell Ghost as Drug Carriers 4.4 Cochleates as Nanoparticular Drug Carriers – 4.5 Aerosols as Drug Carriers 4.6 Magnetic Nanoparticles as Drug Carriers 4.7 Nanoparticulate Drug Delivery to the Reticuloendothelial System and to Associated Disorders 4.8 Delivery of Nanoparticles to the Cardiovascular System 4.9 Nanocarriers for the Vascular Delivery of Drugs to the Lungs 4.10 Nanoparticulate Carriers for Drug Delivery to the Brain 4.11 Nanoparticles for Targeting Lymphatics 4.12 Polymeric Nanoparticles for Delivery in the Gastro-Intestinal Tract – 4.13 Nanoparticular Carriers for Ocular Drug Delivery 4.14 Nanoparticles and Microparticles as Vaccines Adjuvants 4.15 Pharmaceutical NanoCarriers in Treatment and Imaging of Infection

References

1. Nanomedicine Technologies and Applications, (2nd Edition) by Thomas Webster, Elsevier.
2. Handbook of modern sensors-Physics, Designs and applications (5th edition) by Jacob Fraden, Springer
3. Nanomedicine in Drug Delivery, A. Kumar, H. M. Mansour, A. Friedman, E. R. Blough, CRC Press.
4. Understanding Nanomedicine- An Introductory Textbook by R. Burgess,CRC Press.
5. Nanoparticulates as Drug Carriers Edited by Vladimir P.Torchilin, Imperial College Press, (2006)
6. Controlled Drug Delivery: Fundamentals and Applications, Second Edition, J. Robinson, V. H. L. Lee, Taylor & Francis.

Teaching Learning Strategies

- Provide updated Lecture Sessions
- Promote Interactive Sessions including discussions and demonstrations.
- Provide experiments to engage students actively and visual aids like presentations, videos, and models to enhance understanding.
- Encourage students to ask questions during or after the lectures

MODE OF TRANSACTION

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. List some examples of implantable materials and devices used in nanomedicine?
2. Summarize the history of nanomedicine
3. Compare the principle and functions of chemical and molecular sensors.
4. Distinguish between pressure sensors and molecular sensors
5. Analyze the role of cells and cell ghosts as drug carriers

SEMESTER VII
DISCIPLINE SPECIFIC COURSE (DSC)
SPECTROSCOPY I

Course Title	:	**SPECTROSCOPY I**
Course Code	:	**KU07DSCCHE401**
Course Type	:	**DSC**
Course Credits	:	**4**
Pre-requisites	:	**Basic organic concepts, fundamentals of analytical and instrumentation techniques**

Course Objectives

1. To understand the interaction of electromagnetic radiation with matter
2. To impart qualitative and quantitative knowledge about principles and applications of different spectroscopic techniques
3. To learn the basic principle, instrumentation and applications of atomic emission and absorption spectroscopy
4. To learn the basic principle, instrumentation and applications of microwave spectroscopy and electronic spectroscopy

Credit			Teaching Hours			Assessment		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
4	0	4	60	0	60	50	50	100

Course Outcome

CO1	Acquire knowledge on fundamental concepts of interaction of electromagnetic radiation with matter
CO2	Understand various factors affecting the intensity and width of spectral lines
CO3	Acquire knowledge about principle, instrumentation and applications of atomic emission and absorption spectroscopy
CO4	Explain the principle, instrumentation and applications of microwave spectroscopy
CO5	Explain principle, instrumentation and applications of electronic spectroscopy

Mapping of course Outcomes with POs/PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3				3	3	2	2	2	3	1	2
CO 2	3				3	3	2	2	2	3	1	2
CO 3	3				3	3	2	2	2	3	1	2
CO 4	3				3	3	2	2	2	3	1	2
CO 5	3				3	3	2	2	2	3	1	2

Module 1: Foundations of Spectroscopic Techniques **15 hrs**

1.1 Electromagnetic radiation, general nature of electromagnetic waves, wave parameters,1.2 Regions of the spectrum, 1.3 Quantization of energy, 1.4 Interaction of electromagnetic radiation with matter: absorption, spontaneous emission and simulated emission,1.5 Jablonski diagram,1.6 Factors affecting width of spectral lines, 1.7 Factors affecting intensity of spectral lines, signal to noise ratio, 1.8 Transition moment integral, 1.9 Specific and gross selection rules in spectroscopy.

Module II: Atomic Spectroscopy **15 hrs**

2.1 Origin of atomic spectra,2.2Classification of atomic spectroscopic methods: absorption spectra, emission spectra and fluorescence spectra, 2.3 Atomic absorption spectroscopy (AAS): principle of AAS, sample atomization techniques, 2.4 absorption of radiant energy by atoms, measurement of atomic absorption, instrumentation and applications of AAS. 2.5 Atomic emission spectroscopy (AES): principle of AES, sample atomization techniques, origin of spectra, 2.6 Instrumentation and applications of AES.2.7 Principle, instrumentation and application of atomic fluorescence spectra.

Module III: Microwave Spectroscopy **15 hrs**

31. Rotation of molecules, classification of molecules based on principal moments of inertia, 3.2 Rotational spectra of rigid diatomic molecules, 3.3 Gross and specific selection rules in microwave spectroscopy,3.4 Allowed rotational energy levels of a rigid diatomic molecule,3.5 Determination of moment of inertia and bond length of molecules,3.6 Factors affecting the

intensity of rotational spectral lines, 3.7 Effect of isotopic substitution, 3.8 Rotational spectra of non-rigid diatomic molecules, 3.9 Chemical analysis by microwave spectroscopy.

Module IV: Electronic Spectroscopy **15 hrs**

4.1 Introduction to electronic spectroscopy, origin of electronic spectra, singlet and triplet states, 4.2 Selection rules: spin selection rule and Laporte selection rule, 4.3 Electronic transitions in molecules ($\sigma\rightarrow\sigma^*$, $n\rightarrow\sigma^*$, $\pi\rightarrow\pi^*$ and $n\rightarrow\pi^*$), 4.4 Beer-Lambert's law, molar extinction coefficient and its importance, 4.5Chromophores and auxochromes, bathochromic and hypsochromic shifts, 4.6 Effect of conjugation on UV-Visible absorption spectra of molecules, 4.7 Instrumentation and applications of electronic spectroscopy.4.8 Franck-Condon principle: transition, dissociation and predissociation.

References

1. Banwell, C. N. &Mc Cash, E. M. Fundamentals of Molecular Spectroscopy,4th Ed. Tata McGraw-Hill: New Delhi (2006).
2. P. S. Kalsi, Applications of Spectroscopic Techniques in Organic Chemistry, 6th Edn.,
3. New Age International (P) Ltd., New Delhi, 2004
4. D. L. Pavia, G. M. Lampman, G. S. Kriz, Introduction to spectroscopy, 3rd edn, Thomson Brooks/Cole, 2001
5. T. Engel, Quantum Chemistry and Spectroscopy, Pearson Education, 2006.
6. K.Veera Reddy, Symmetry and Spectroscopy of molecules,New Age International (P) Ltd,1999
7. Aruldhas, Molecular Structure and Spectroscopy, 2nd Edn., Prentice Hall India, 2007
8. P Gupta, S. S. Das, N. B. Singh, Spectroscopy, Jenny Stanford Publishing, 2023.
9. F. Bernath, Spectra of Atoms and Molecules, 2nd Edn., Oxford University Press, 2005
10. N. Sathyanarayana, Introduction to Magnetic Resonance Spectroscopy ESR, NMR, NQR., IK International, ISBN: 9789380026251
11. Robert L. Carter, Molecular Symmetry and Group Theory, Wiley, 1997, SBN: 978-0-471-14955-2

Teaching Learning Strategies

- Provide updated Lecture Sessions
- Promote Interactive Sessions including discussions and demonstrations.
- Provide experiments to engage students actively and visual aids like presentations, videos, and models to enhance understanding.
- Encourage students to ask questions during or after the lectures

Mode of Transaction

- Lectures, seminars, discussions, and demonstrations

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. State and explain Franck – Condon principle
2. Discuss rotational spectrum of a polyatomic symmetric top molecule.
3. Write a short note on various factors affecting intensity of spectral lines
4. Explain the basic principle of AAS
5. What are the gross and specific selection rules in microwave spectroscopy?

DISCIPLINE SPECIFIC COURSE (DSC)

PROGRESSIVE ORGANIC CHEMISTRY

Course Title	:	**PROGRESSIVE ORGANIC CHEMISTRY**
Course Code	:	**KU07DSCCHE401**
Course Type	:	**DSC**
Course Credits	:	**4**
Pre-requisites	:	**Spectroscopy, absorbance and transmittance, types of organic substitution groups, organic reagents, synthetic strategy**

Course Objectives:

- Learn the importance and applications of spectroscopic techniques such as UV, IR and NMR
- Analyse the elucidations of organic compounds using spectral data
- Learn the various reagents and their uses in organic synthesis
- Acquire knowledge about the different techniques and methods used in organic synthesis

Course Outcomes

CO1	Understand the instrumentation and sampling techniques for various spectroscopy
CO2	Elucidate synthesized organic molecules using spectral data
CO3	Describe the various reagents and their functions in synthesizing new products
CO4	Illustrate advanced methods of organic synthesis with new protocol.

Mapping of Course Outcome to POs/PSOs

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	1	1	2	3	3	2	1	1	2	3
CO2	3	3	2	3	3	3	2	2	2	1	1	1
CO3	3	2	3	1	2	2	1	3	1	3	3	3
CO4	3	1	1	2	1	1	1	1	3	2	1	1

Module 1 Basic Organic Spectroscopy 15 hrs

1.1Ultraviolet and visible spectroscopy: sampling, solvent effects, limitations, applications1.2Woodward-Fieser method of calculations1.3Infrared spectroscopy: factors influencing vibrational frequencies, sampling techniques, effect of solvents1.4IR group frequencies: identifications and applications1.5Quantitative infrared analysis, Attenuated Total Reflectance, Photo-Acoustic Spectroscopy, Multiple Internal Reflectance spectroscopy1.6Proton NMR spectroscopy: Chemical shift, spin-spin splitting and coupling constants1.7Applications of NMR to organic compounds1.8Coupling of proton to other nuclei (^{19}F, ^{15}N, ^{31}P, ^{29}Si)1.9Structural elucidation problems based on UV-Visible, InfraRed and ^{1}H-NMR spectroscopies

Module 2 Advanced Organic Spectroscopy 15 hrs

2.1Carbon-13 NMR spectroscopy: off-resonance and proton decoupling2.2Nuclear Over Hauser Effect and applications2.3Advanced NMR techniques: DEPT, HMQC and HSQC techniques2.4ESR spectroscopy2.5Structural elucidation of organic compounds based on ^{1}H-NMR and ^{13}C-NMR2.6Structural elucidation of organic compounds based on IR and ^{1}H-NMR and ^{13}C-NMR spectral data2.7Mass spectroscopy: Theory and instrumentation2.8Mass spectroscopy: Fragmentation methods, 2.9McLafferty rearrangement, 2.10Combined GC-MS and LC-MS methods, application studies, 2.11Structural elucidation of organic compounds based on UV, IR, NMRs and MS data

Module 3 Reagents in Organic synthesis 15 hrs

3.1Oxidation and reduction reagents3.2Metal and non-metal based oxidation and reduction reagents3.3Catalytic hydrogenation and stereochemistry3.4Reduction using $LAlH_4$, $NaBH_4$ and $NaCNBH_3$3.5Synthesis and synthetic applications of crown ethers, 3.6Synthetic uses of reagents such as NBS, DDQ and DCC. Gilmann reagent, 3.7Use of sulphur, phosphorous, Silicon, Mercury and cadmium containing reagents, 3.8Application of organometallic reagents in organic synthesis, 3.9Use of Platinum and palladium reagents in organic synthesis, 3.10Applications of transition metal catalysts in organic synthesis, 3.11Olefin metathesis and Grubbs catalysts, 3.12Enzyme catalyzed reactions in organic synthesis,

Module 4 Modern Methods of Organic Synthesis 15 hrs

4.1Retrosynthetic Analysis: Basic principles and terminology of retrosynthesis4.2Synthesis of aromatic compounds, one group and two group C-X disconnections4.3Important strategies of retrosynthesis4.4One group C-C and two group C-C disconnections4.5Amine and alkene synthesis usis disconnection methods4.6Umpolung equivalent. oftrimethylsilyl group in organic synthesis4.7introduction to Combinatorial chemistry and Click chemistry-the one pot synthesis4.8Fundamentals of Supramolecular Chemistry4.9Functional group transposition, 4.10Polymer supported reagents in organic synthesis

References

1. Application of Transition Metal Catalysts in Organic Synthesis, H. D. Verkruijsse, L. Brandsma, and S.F. Vasilevsky, Springer (2010)
2. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, 2ndedn, Oxford University Press (2012).
3. Fundamentals of Fourier Transform Infrared Spectroscopy, Brian C. Smith, CRC Press Organic Spectroscopy William. Kemp, Plagrave publishers (2016)
4. Guide to Organic Spectroscopy, Dipti K. Dodiya, Clever Fox Publishing (2022)
5. Introduction to Organic Mass Spectrometry, SiddiquiAnees A CBS Publishers (2021)
6. Introduction to Organic Spectroscopy, Donald L. Pavia, Gary M. Lampman, George S. Kriz and James A. Vyvyan, Cengage India Private Limited; (2015)
7. Modern Infrared Spectroscopy, Barbara Stuart, Bill George, Peter McIntyre, Wiley India Pvt. Ltd (1995)
8. Modern Organic Chemistry, Jain M.K, Sharma S.C. Vishal Publishing Co., (2018)

9. Modern Techniques of Spectroscopy Basics Instrumentation and Applications, Singh D.K., Springer (2021)
10. Organic Chemistry Reactions & Reagents, Agarwal O.P., 49th ed., Goel Publishing House, (20140.
11. Organic Chemistry, Carey Francis A., 7th ed., New Delhi, Tata McGraw Hill Education Pvt Ltd., (2009).
12. Organic Chemistry, Graham Solomons T.W., 3rd ed., John Wiley &Sons (1984).
13. Organic Chemistry, John E. McMurry, 9th ed., Cengage Learning, (2015).
14. Organic Spectroscopy (NMR, IR, Mass and UV), S.K. Dewan, Atithi Books (2019)
15. Organic Spectroscopy, Jag Mohan , Narosa Publishing House (2009)
16. Organic Spectroscopy, PradeepPratap Singh Ambika, Viva Books (2018)
17. Organic structural spectroscopy, J.B. Lambert, H.F. Shurvell, D.A. Lightner and R.G. Cooks, Prentice hall (2010)
18. Organic Structures from Spectra, L D Field, H.L. Li, A.M. Magill, Wiley (2020)
19. Organic Synthesis through Disconnection Approach, P S. Kalsi, Med Tech (2022)
20. Organic Synthesis, The disconnection Approach, Stuart Warren, Paul Wyatt, Wiley (2008)
21. Reagents for High-Throughput Solid-Phase and Solution-Phase Organic Synthesis, Jonathan A. Ellman , John Wiley, (2005)
22. Spectrometric Identification of Organic Compounds, R.M. Silverstein, G.C. Bassler, T.C. Morril, John Wiley (1991)

Teaching Learning Strategies

- Explaining the advances in the subject
- Providing application oriented knowledge of the subject
- Allowing to practice the subject with examples
- Illustrating the application of the titled course to the society

Mode of Transactions

• Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50

Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Discuss the various sampling techniques of IR spectroscopy
2. What is Nuclear Overhauser Effect? What is its application?
3. What is olefin metathesis?
4. Discuss the terminology of retrosynthetic analysis

DISCIPLINE SPECIFIC ELECTIVE (DSE)

ORGANIC CHEMISTRY PRACTICAL II

Course Title	**:**	**Organic Chemistry Practical II**
Course Code	**:**	**KU07DSECHE403**
Course Type	**:**	**DSE**
Course Credits	**:**	**4**
Pre-requisites	**:**	**Organic Reactions and Synthesis**

Course Objectives:

- To learn the basic organic separation analysis of acids, bases, phonolic and neutral compounds from one another.
- To learn the method of double stage synthesis of organic reactions
- To learn the extraction techniques of natural products.
- To understand the synthesis of organic molecules by multi-step synthesis strategies.

Credit			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
0	4	4	0	4	4	50	50	100

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

C01	Separate the organic mixtures into single components
C02	Estimate the percentage content of phenol, aniline and glucose
C03	Prepare new compounds applying many reactions and identify them using physical parameters
C04	Learn the extraction techniques of natural products

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO 2	PSO 3	PSO 4	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
C01	2	3	3	2	2	3	1	1	1	2	1	2
C02	2	3	3	2	2	3	1	1	1	2	1	2
C03	2	3	3	2	2	3	1	1	1	2	1	2
C04	2	3	3	2	2	3	1	1	1	2	1	2

Module 1 **Analysis of organic binary mixture** **30 hours**

Separation and identification of organic binary mixtures (min 8 numbers) containing two components with at least two substituents in any one of the components. Recrystallization, determination of physical constants and preparation of derivatives

Module 2 **Physical Organic Experiments** **30 hours**

Estimation of phenol/ aniline, estimation of glucose, equivalent weight of carboxylic acid, Estimation of lactose in milk, Determination of saponification/ iodine value of an oil

Module 3 **Preparative organic chemistry** **30 hours**

Multi stage preparation and identification of organic compounds. (Any 4)

1. Preparation of tribromo benzene from aniline.
2. Preparation of nylon from cyclohexanone via caprolactam.
3. Preparation of phenolphthalein.
4. Preparation of methyl orange.

Module 4 **Bio-Organic Techniques** **30 hours**

Soxhlet Extraction: Tulsi, Neem, Aloe vera, Ginger etc.

References:

1. A Text Book of Practical Organic Chemistry, A I Vogel, ELBS.
2. Advanced Practical Organic Chemistry, J. Leonard, B, Lygo and G. Procter, Nelson Thornes
3. Lab experiments in organic chemistry, A. Sethi, New Age international
4. Organic synthesis special techniques,V.K.Ahluwalia,RenuAggarwal
5. Practical Organic Chemistry", F.G. Mann and B C Saunders, Longman.
6. Systematic identification of organic compounds, Shriner, Hermann, Morrill, Curtin and Fuson, John Wiley
7. Vogel's Textbook of practical organic chemistry, B.S. Furniss, A.J. Hannaford, Pearson Education 33
8. Laboratory Manual in Organic Chemistry–Dey&Sitaraman(Allied , New Delhi)1992

Teaching Learning Strategies

- Provide experiments to engage students actively and visual aids like presentations, videos, and models to enhance understanding.
- Encourage students to ask questions during or after the practical.
- Allow students to conduct experiments under supervision.
- Provide students with the required safety instructions and guidelines for lab work

Mode of transaction

- Discussions and demonstrations.

ASSESSMENT RUBRICS			Total
End Semester Evaluation	External Exam	50	50
Continuous Evaluation	Internal Exam	40	50
	Viva	10	

Sample Questions to test Outcomes.

1. Write a note on Soxhlet extraction of thulsi.
2. Explain the chemistry behind the preparation of nylon.
3. Explain electrophilic substitution reaction with example
4. Discuss the order of reagents used for separation of organic compounds
5. Explain the organic reaction for the synthesis of tribromo benzene from aniline.

DISCIPLINE SPECIFIC ELECTIVE (DSE)

SUPER CAPACITORS FOR ELECTROCHEMICAL ENERGY STORAGE

Course Title	:	**SUPER CAPACITOS FOR ELECTROCHEMICAL ENERGY STORAGE**
Course Code	:	**KU07DSECHE404**
Course Type	:	**DSE**
Course Credits	:	**4**

Pre-requisites : **Basic awareness of concepts in Electrochemistry**

Course Objectives:

1. To acquire awareness on the concept of supercapacitor as an energy storage device and their different variations.
2. To gain understanding of processes and mechanisms happening in a supercapacitor system and characterization techniques to understand the same.
3. To understand different parameters that affect the performance of a supercapacitor.

Credits			TeachingHours			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

Course Outcome

C 01	Explain the fundamentals and opportunities of Supercapacitors as an energy storage device.
C 02	Classify different types of supercapacitors based on their storage mechanisms
C 03	Explain the mechanisms involved in the charge storage process of a supercapacitor and the factors that affect the same.
C 04	Interpret the effect of different constituents of a supercapacitor system while also considering their sustainability and their impact on the storage efficiency.
C 05	Ability to theoretically design a full cell supercapacitor system in terms of it's constituents based on the energy and power requirement.

Mapping of Course Outcomes to POs/PSOs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	2	2	2	3	3	2	1	1	2	1	1
CO2	3	2	2	2	3	2	1	1	1	3	2	1
CO3	3	3	3	1	3	3	2	1	1	3	1	1
CO4	3	3	3	2	3	3	2	2	2	2	3	1
CO5	3	3	3	2	3	3	1	2	1	2	2	2

Module 1 Fundamentals of Electrochemistry 15 hours

1.1EMF, Redox potential, Faraday Law, Nernstlawetc, 1.2 Electrochemical energy storage systems: Primary and secondary batteries, supercapacitors, 1.3 calculation of theoretical capacitance, 1.4 Kinetics and thermodynamics of electrochemical cells, Double layer effects in electrode kinetics

Module 2 Basics of Supercapacitors 15 hours

2.1History of supercapacitors, 2.2 Classification: EDLC, Pseudocapacitors, Hybrid capacitors, 2.3 Materials and methods: Electrodes (Carbon, Metal Oxides, metal chalcogenides and Conducting polymers), Electrolytes (aqueous, Organic and ionic liquid solvents), Current collectors and separators and their syntheses, 2.4 parameters that affect the performance of these elements, 2.5 Electric double layer at the interface: modeling, surface functionalities of carbon, 2.6 Fabrication of fully functional prototypes: Symmetric and asymmetric, mass balancing, 2.7 factors to be considered.

Module 3 Characterization of Supercapacitors 15 hours

3.1Single electrode and full cell characterization, 3.2 Cyclic voltammetry, 3.3 Galvanostatic charge discharge, 3.4 nominal voltage, 3.5 rate performance, 3.6 self discharge, 3.7 Leakage current, 3.8 Impedance spectroscopy measurement and analysis, Frequency response of electric double layer capacitors, 3.9 Electrochemical behavior of specific common anode materials: RuO_2, NiO, activated carbon, Graphene etc.

Module 4 Innovative technologies and applications 15 hours

4.1 Microsupercapacitors, 4.2 Flexible SCs, 4.3 Shape memory SCs, 4.4 piezoelectric SCs, 4.5 Transparent SCs, 4.6 Major application areas: Portable electronics, Smart devices, Biological systems, UPS, Load leveling, Electric and Hybrid electric vehicles, Power harvesting and storage systems, military and defense applications etc, 4.7 Specifications to be met in terms of the applications, 4.8 Future perspectives and challenges.

References

1. Conway, Brian E. Electrochemical supercapacitors: scientific fundamentals and technological applications. Springer Science & Business Media, 2013.
2. Khan, A., Asiri, A. M., & Kolosov, A. E. (2022). Handbook of Supercapacitor Materials. R. Boddula (Ed.). Wiley-VCH.
3. Paravannoor, Anjali, and K. V. Baiju, eds. Supercapacitors and Their Applications: Fundamentals, Current Trends, and Future Perspectives. CRC Press, 2023.

4. Stevic, Zoran, ed. Supercapacitor Design and Applications. BoD–Books on Demand, 2016.

Teaching Learning Strategies

- Provide updated Lecture Sessions
- Promote Interactive Sessions including discussions and demonstrations.
- Provide experiments to engage students actively and visual aids like presentations, videos, and models to enhance understanding.
- Encourage students to ask questions during or after the lectures

MODE OF TRANSACTION

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Explain the working principle of an Electric Double Layer Capacitor?
2. Briefly explain the application of metal oxide materials in supercapacitors?
3. Give an account on the Impedance spectroscopy of the characterization of a pseudocapacitor system?
4. Write a note on the applications of Nanomaterials?

DISCIPLINE SPECIFIC ELECTIVE (DSE)
SUPRAMOLECULAR CHEMISTRY

Course Title	:	**SUPRAMOLECULAR CHEMISTRY**
Course Code	:	**KU07DSECHE405**
Course Type	:	**DSE**

Course credit : **4**

Prerequisites : **Basic concepts in Organic reaction mechanism**

Course Objectives:

- The course cover the fundamentals of supramolecular chemistry, emphasizing the interaction between molecules and creation of compounds that may bind to one another.
- The application of super molecules in material science and chemical biology are discussed in detail.

Credits			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

Course Outcomes:

CO1	To understand the fundamentals of supremolecular chemistry.
CO2	Demonstrate knowledge of the synthesis and properties ofsupermolecules.
CO3	Describe the application of supramolecular chemistry inorganic chemistry, material science, chemical biology, and nanotechnology.
CO4	Discuss how supramolecular chemistry can facilitate sustainable development.
CO5	Understand and discuss current research questions in the field.

Module 1: Fundamentals **15 hours**

Host-Guest chemistry: The meaning of supramolecular chemistry, classification of host-guest compounds, non-covalent associations, complementarity.

Molecular recognition: Host design, acyclic receptors for neutral and charged guests, macrocycles and crown ethers, macrobicycles and cryptands, clathrates, cyclophanes, cyclodextrins, calixarenes, cucurbiturils.

Module 2: Supramolecular devices **15 hours**

Supramolecular devices: Sensors and information processing, electro-optic phenomenon, molecular clefts, tweezers, and devices.

Module 3Supramolecular aggregates **15 hours**

Amphibilic molecules and their aggregation: micelle, vesicles, liposomes, microemulsions, H and J-aggregate, aggregation induced emission and quenching, Langmuir Blodgett method, molecular recognition at the air water interface.

Module 4: Super molecules in real world **15 hours**

Discrete and polymeric metal organic hybrid materials: guest inclusion, catalysis and other applications.

Natural processes: Peptide self-assembly, Protein and DNA aggregation, amyloid and cell membrane.

Reference

1. Supramolecular chemistry: Concepts and Perspectives, J. –M. Lehn, VCH, Weinheim, 1995.

2. Principles and Methods in Supramolecular Chemistry, H. J. Schneider and A. Yatsimirsky, Wiley, New York, 2000.

3. Supramolecular Chemistry, J. W. Steed and J. L. Atwood, John Wiley & Sons, Chichester, 2009.

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	3	3	2	3	2	2	3	2	3
CO2	3	2	2	3	3	3	3	2	2	3	2	3
CO3	3	3	3	3	3	3	3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3	3	3

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting Active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminars	10	
	Viva	10	

Sample Questions to test Outcomes

1. Explain different types of non covalent interactions inside a supermolecule with suitable examples.
2. Give an account on supramolcular devices.
3. Comment on J- and H- type aggregates.
4. Discuss hydrogen bonding interaction between nitrogen bases in DNA molecule.

DISCIPLINE SPECIFIC ELECTIVE (DSE)
FOOD CHEMISTRY

Course Title	:	**FOOD CHEMISTRY**
Course Code	:	**KU07DSECHE406**
Course Type	:	**DSE**
Course Credits	:	**4**

Pre-requisites : **Basic Knowledge in Biochemistry, bioinorganic Chemistry, basic structure protiens, amino acids**

Course Objectives:

- This course aims to teach students about foods as chemical systems.
- Outlining the nutrients, or necessary food components, that comprise these systems
- The processes that underlie the changes that take place to food as it is processed and stored.
- Students will be conversant with food nanotechnology and analytical methods.

Credit			Teaching Hours			Assessment		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
4	0	4	4	0	4	50	50	100

Course outcomes:

After the completion of the course, the learners should be able to

C01	Understanding fundamentals of food chemistry
C02	To acquire knowledge in Food Additives, Preservatives, and Contaminants
C03	To gain concepts on food composition and nutritional aspects
C04	Familiarity with analytical methods and Nanotechnology in food science

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	1	1	2	3	2	2	2	1	3	2	2
CO2	2	1	2	2	3	2	2	2	1	3	2	2
CO3	2	1	2	2	3	2	2	2	1	3	2	2
CO4	3	1	2	2	3	2	2	2	1	3	2	2

Module 1: Chemistry of food: Ingredients and Flavor enhancers 15 hours

1.1 Introduction, Historical development of food chemistry. 1.2 Food Constituents- Carbohydrates-classification and physical properties, changes of carbohydrates on cooking. 1.3 Lipids-occurrence in food and composition, fats and oils, 1.4 Hydrogenation, Rancidity, reversion, rendering, extraction and refining. 1.5 enzymes- classification and properties, vitamins-fat and water soluble, peptides, amino acids and protein-physical properties.1.6

Protein sources, Protein denaturation.1.7 Determination of proteins in food. Minerals obtained from food. 1.8 Synthetic and natural Aroma compounds, Aroma value and threshold value. 1.9 Sweeteners-Saccharin, Cyclamate, Aspartame. MSG as flavouring enhancer.

Module 2: Chemistry of Food: Additives, Preservatives, and Contamination 15 hours

2.1 Chemical Aspects of Additives, and Preservatives. 2.2 Categories of Food Colours. Water Soluble and fat-soluble Synthetic Colours. 2.3 Classification of Food Colorants-Natural and synthetic colorants. 2.4 Classification of Food Additives. 2.5 Food Spoilage and Preservation: Causes of Spoilage, 2.6 Principle of Food Preservation. Factors Affecting Chemical Preservation, Classification of Chemical Preservatives, Types of Chemical Preservatives, Natural Chemical Preservatives, Methods of Food Preservation. 2.7 Advantages and disadvantages of Food Additives and Preservatives. Effects and safety of Food Additives and Food Preservatives.2.8 History and types of Food Adulteration: Intentional, Incidental and Metallic Adulteration. Food contamination-Toxic trace elements and compounds.

Module 3:Chemical Composition of Food and Nutritional Aspects 15 hours

3.1 Chemical Composition of Food and Food Commodities-Beverages and Drinks, 3.2 Cereals and Their Products, 3.3 Eggs and Egg Products, Edible Fats and Oils, Fish and Fishery Products, Meat and Meat Products, Milk and Milk Products. 3.3 Composition of chemicals in vegetables and fruits. 3.4 Compositions of tea and coffee. Composition of Honey and artificial honey.3.5 Raw materials and brewing process of beverages. 3.6 Nutritional and Toxicological Aspects of the Chemical Changes of Food Components and Nutrients During Drying, During Freezing, During Heating and Cooking. 3.7 Nutritional Values of Fermented Foods, Nutritional Quality of Fermented Vegetables and Fruits

Module 4:Analytical Methods and Nanotechnology in Food 15 hours

4.1 Chemical Analysis of Food Components: Classical Wet Chemistry Methods, Sampling and Sample Preparation, 4.2 Instrumental Food Analysis. Analysis of drinking water.Standards for mineral water.4.3 An Introduction to Food Nanotechnology, Applications of Nanotechnology in Developing Biosensors for Food Safety, 4.4 Advances of Nanomaterials for Food Processing. Bioactive Ingredients in Functional Foods and Nutraceuticals.4.5 Bioactive Substances of Plant Origin, Animal Origin, Microbial Origin and Synthetic Bioactive Substances.

References

1. MousumiSen, Food Chemistry: The Role of Additives, Preservatives and Adulteration

2. Peter C. K. Cheung, Bhavbhuti M. Mehta, Handbook of Food Chemistry.

3. Owen R Fennema, Food Chemistry

4. H.D. Belitz, W. Grosch, P. Schieberle, Food Chemistry

5. Lillian Hoagland Meyer, Food Chemistry, CBS Publishers and Distributors

6. HD Belitz, W. Grosch, P Schieberle, Food Chemistry, Springer 4thEdn.

7. Matthew Hartings, Chemistry in your Kitchen, Royal Society of Chemistry

8. J. R. Hanson, Chemistry in the Kitchen Garden, RSC Publishing.

Teaching Learning Strategies

- Provide updated Lecture Sessions
- Promote Interactive Sessions including discussions and demonstrations.
- Provide experiments to engage students actively and visual aids like presentations, videos, and models to enhance understanding.
- Encourage students to ask questions during or after the lectures

MODE OF TRANSACTION

• Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes.

1. Explain the different food additives used
2. Analyse different method of food preservation, and comment on it
3. Distinguish between bioactive substance of plant origin and animal origin with examples
4. Describe advanced nanomaterial techniques for food processing.

DISCIPLINE SPECIFIC ELECTIVE (DSE)
NUCLEAR CHEMISTRY

Course Title : **Nuclear Chemistry**

Course Code : **KU07DSECHE407**

Course Type : **DSE**

Course credit : **4**

Prerequisites : **Basic atomic structure**

Course Objectives

- The course covers basic principles of structure of atomic nucleus, radioactivity and its use in Nuclear reactors, ^{14}C dating etc.

Credits			Teaching Hours			Assessment		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
4	0	4	4	0	4	50	50	100

Course Outcomes:

CO1	Understand the basic structure of atomic nucleus.
CO2	Identify kinetics of radioactive decay in elements to use in calculation of half life and mean life period.
CO3	Appreciate principles and measurement of radioactivity.
CO4	Recognize the working principle of nuclear reactors.
CO5	Aware of the merits and demerits of radioactivity.

Module 1: Structure of atomic nucleus **15 hours**

Nucleus and its structure, nuclear forces, nuclear stability, binding energy, magic numbers, Odd-Even rule, Semi Empirical Mass equation, Nuclear moments, Nuclear models. Types of nuclear reactions, fission and fusion, Stellar energy.

Module 2: Radioactivity **15 hours**

Radioactive elements, Natural and induced radioactivity, Radioactive decay, Group displacement law, general characteristics of radioactive decay, Radioactive decay andgrowth, decay kinetics - decay constant, half-life, mean life period, Radioactive equilibrium, Secular and Transient Equilibrium, Units of radioactivity and radiation energy.

Module 3: Nuclear reactors **15 hours**

Measurement of radioactivity, Geiger-Muller detector, Scintillaton detectors, Nuclearreactors: classification of reactors, uranium reactor, breeder reactor. Nuclear reactors in India (Brief Idea).

Module 4: Pros & Cons of Radioactivity **15 hours**

Nuclear pollution and Radiological safety: Interaction of radiation with matter, Radiolysis of water, Radiation dosimetry, Fricke Dosimeter, Radioactive isotopes and their applications,

^{14}C dating,Rock dating, Isotopes as tracers,Radio diagnosis and radiotherapy, radio-analytical techniques and activation analysis. Isotopic dilution analysis, Neutron activation analysis, Disposal of nuclear waste, nuclear disaster (nuclear accidents– discussion about case studies).

References

1. H.J. Arnikar, Essentials of Nuclear Chemistry, Wiley Eastern, 1982.
2. S.N. Goshal, Nuclear Physics, S. Chand and Company, 2006.
3. Elements of Nuclear Chemistry, R. Goplalan, Vikas Publishers, 2000.
4. Introduction to Radiochemistry, G. Friedlander and J. W. Kennedy, JohnWiley and Sons.
5. Introduction to Radiochemistry, G. Friedlander and J. W. Kennedy, JohnWiley and Sons.
6. Nuclear Chemistry, C. V. Shekar, Dominant Publishers, 2014
7. Radiochemistry and Nuclear Chemistry, G. R. Choppin, J-O. Liljenzin and J.

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3	3	2	2	3
CO2	3	3	3	3	3	3	3	2	2	3	3	3
CO3	3	3	3	3	3	3	3	3	3	2	2	3
CO4	3	3	3	3	3	3	3	3	3	2	2	3
CO5	3	3	3	3	3	2	3	3	3	3	3	3

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting Active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminars	10	

	Viva	10	

Sample Questions to test Outcomes

1. Demonstrate structure of atomic nucleus. Describe magic number.
2. What do you mean by: (a) decay constant, (b) half life and (c) mean life period.
3. Write a note on working of breeder reactor.
4. Describe Chernobyl disaster.

SEMESTER VIII
DISCIPLINE SPECIFIC CORE (DSC)
GROUP THEORY

Course Title	:	**Group Theory**
Course Code	:	**KU08DSCCHE408**
Course Type	:	**DSC**
Course Credits	:	**4**
Pre-requisites	:	**Basic organic concepts, Fundamentals of analytical and instrumentation techniques**

Course Objectives

1. To develop an understanding of the principles of molecular symmetry.
2. To provide advanced knowledge on fundamental aspects of classifying molecules based on various symmetry elements, point groups and relate their vibrational spectroscopic features.
3. To describe product of symmetry operation and character table of chemical compounds.
4. Make use of character table to predict the spectroscopic properties of the molecule

Credit			Teaching Hours			Assessment		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
4	0	4	60	0	60	50	50	100

Course Outcome

CO1	Acquire knowledge on symmetry elements and symmetry operations
CO2	Predict the symmetry of a molecule or an object
CO3	Identify point groups and construct character table of molecules

CO4	Predict the spectroscopic properties of a molecule using its character table
CO5	Predict hybridization and spectral properties based on symmetry of molecule

Mapping of course Outcomes with POs/PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	2	3	3	3	3	3	2	2	2	3	1	2
CO 2	3	3	3	3	3	3	2	2	2	3	1	2
CO 3	3	3	3	3	3	3	2	2	2	3	1	2
CO 4	3	3	3	3	3	3	2	2	2	3	1	2
CO 5	3	3	3	3	3	3	2	2	2	3	1	2

Module 1: Symmetry Elements and Point Groups **15 hrs**

1.1 Importance of symmetry, indistinguishable configurations, 1.2 Symmetry elements and symmetry operations in molecules: identity element, centre of symmetry, plane of symmetry, proper axis and improper axis of rotation, 1.3 Product of symmetry operations, 1.4 Commutative symmetry operations, 1.5 Mathematical rues for the formation of a group, 1.6 Definition and classification of point groups, 1.7 Cyclic point groups, 1.8 Order of a group, 1.9 Similarity transformation, conjugate elements and classes of a group.

ModuleII: Group Multiplication Tables and Matrix Representations **15 hrs**

21. Group multiplication tables(C_{2V} and C_{3V}), 2.2 Subgroups, 2.3 Isomorphic groups, abelian groups, 2.4 Applications of point group assignments: prediction of optical activity and dipole moment of molecules, 2.5 Symmetry number, 2.6 Similarity transformations of matrices, addition and multiplication of matrices, adjoint and inverse of a matrix, character of a matrix, 2.7 Block diagonalisation,solutions of linear equations by matrix method, 2.8 Matrix representation of symmetry operations.

Module III: Reducible and Irreducible Representations **15 hrs**

3.1 Matrix representation of point groups, construction of matrix representation using vectors and atomic orbital as basis, 3.2 Matrix representation generated by cartesian coordinates positioned on the atoms of a molecule (H_2O as example), 3.3 Reducible and irreducible representations, 3.4 Construction of irreducible representation by reduction, 3.5 Great Orthogonality Theorem (GOT), rules derived from the GOT, 3.6 Properties of irreducible representations, 3.7 Construction of irreducible representation using GOT, 3.8 Construction of character tables (C_{2V}, C_{3V}, C_{4V}).

Module IV: Applications of Group Theory 15 hrs

4.1 Determination of symmetry of vibrational modes in H_2O and NH_3 molecules, 4.2 Infrared and Raman activity of molecular vibrations, 4.3 Selection rules for vibrational absorption, 4.4 Complementary character of IR and Raman spectra - mutual exclusion principle,4.5 determination of the number of active IR and Raman lines, 4.6 Determination of symmetry of hybrid orbitals for a tetrahedral molecule, 4.7 Construction of hybridization orbitals for AB_3(triangular planar geometry) and AB_5(trigonal bipyramidal and square pyramidal geometry) molecules.

References

1. F.A. Cotton, Chemical Applications of Group Theory, 3rdEdn., Wiley Eastern, 1990.
2. S. Swarnalakshmi, T. Saroja, R.M. Ezhilarasi, A Simple Approach to Group Theory in Chemistry, Universities Press, 2008.
3. A.S. Kunju, G. Krishnan, Group Theory and its Applications in Chemistry, PHI Learning, 2010
4. P.W. Atkins, R.S. Friedman, Molecular Quantum Mechanics, 4thEdn., Oxford University Press, 2005.
5. K.Veera Reddy, Symmetry and Spectroscopy of molecules, New Age International (P) Ltd,1999.
6. Lowell H. Hall, Group Theory and Symmetry in Chemistry, 1969
7. Alan Vincent, Molecular Symmetry and Group Theory: "A Programmed Introduction to Chemical Applications", 2nd Edition, Wiley
8. Tinkham, Michael. Group Theory and Quantum Mechanics. Dover Publications, 2003. ISBN: 9780486432472.
9. Roy McWeeny, An Introduction to Group Theory and Its Applications, Courier Corporation, 2012
10. A L Gupta, Mukesh Kumar, Group theory and spectroscopy, PragthiPrakashan,

11. Mark Ladd, Symmetry and Group Theory in Chemistry, ScienceDirect, 1998
12. Richard C Powell, Symmetry, Group Theory, and the Physical Properties of Crystals, Springer, 2010

Teaching Learning Strategies

- Provide updated Lecture Sessions
- Promote Interactive Sessions including discussions and demonstrations.
- Provide experiments to engage students actively and visual aids like presentations, videos, and models to enhance understanding.
- Encourage students to ask questions during or after the lectures

Mode of Transaction

- Lectures, seminars, discussions, and demonstrations

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. List and sketch the different symmetry elements present in benzene molecule. Determine its point group.
2. Find the matrix representation for total movement of water molecule.
3. What are reducible and irreducible representations?
4. Construct C_{2V} group multiplication table.
5. State Great Orthogonality Theorem and apply this to construct the character table for C_{2V} point group.

DISCIPLINE SPECIFIC ELECTIVE (DSE)
FORENSIC CHEMISTRY & TOXICOLOGY

Course Title	:	**Forensic Chemistry & Toxicology**
Course Code	:	**KU08DSECHE409**
Course Type	:	**DSE**
Course Credits	:	**4**
Pre-requisites	:	**basic concepts of chemical analysis**

Course Objectives:

- To learn about the drugs and their abuse with their various identification techniques.

- To study various types of poison, their nature, action & symptoms with standard examination procedures in poisoning cases.
- To gain knowledge about ADME of poisons and methods of collecting and preserving evidence.
- To understand the basics of Forensic Chemistry & Toxicology, their scope, role & significance.

Credit			Teaching Hours			Assessment		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
4	0	4	4	0	4	50	50	100

Course outcomes:

C01	Learn about the drugs and their abuse with their various identification techniques.
C02	Learn about various types of poison, their nature, action signs& symptoms with the standard examination procedure in poisoning cases.
C03	Gain knowledge about ADME of poisons and methods of collecting and preservingevidence.
C04	Applythe basics of Forensic Chemistry & Toxicology, their scope, role & significance.

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	3	3	1	2	2	2	2	1	2	1	1
CO2	2	3	3	1	2	2	2	2	1	2	1	1
CO3	3	3	3	1	3	3	2	2	1	3	1	2
CO4	3	3	3	2	3	3	2	2	2	3	1	2

Module I: Introduction to Forensic Chemistry 15 hours

1.1 Role of Forensic Chemist, Types of Cases which require Chemical Analysis, Sampling of Evidences, Presumptive Tests (Colour/Spot Tests), Microcrystal Tests, 1.2 Limitations of Forensic Samples, 1.3 Elemental Analysis (Organic and Inorganic), Instrumental Methods and Equipment. Examination of Contact Traces1.5 Introduction to Cosmetics and Detective Dyes, Collection, Sampling, Analysis and Forensic Importance,1.4 Analysis of Illicit Liquors including Methyl and Ethyl Alcohol1.5 Drugs of Abuse: Introduction, Drug Addiction and its Problems,1.6 Classification of Drugs of Abuse,1.7 Analgesics, Depressants, Stimulants, Hallucinogens, and Narcotics

Module II: Instrumentation for Forensic Analysis 15 hours

2.1 Instrumental Methods: Sample preparation, calibration of instruments for accuracy and reproducibility of results in forensic analysis, method validation technique and requirements, procurement of standard samples,2.2Forensic applications of TLC, HPTLC, HPLC, GC, FT-IR, AAS, GC-MS, UV-visible spectrophotometer with emphasis over standard operational procedures (SOPs) for test samples,2.3 Physical, Biological and Chemical Methods: Non-destructive testing probes including radiography, X-ray-radiography, Surface penetrations method (SEM and Laser Probes),2.4 Fluoroscopy,2.5 Clinical methods: ELISA, RIA and immune-diffusion, 2. 6 analysis of glucose,bilirubin, total cholesterol, 2.7 creatinine, blood urea nitrogen and barbiturates in biological fluids, DNA-finger printing

Module III: Management of Toxicological Cases 15 hours

3.1Introduction, Principles of Management of Poisoning Cases, Duties of a Doctor in Poisoning Cases, Signs and Symptoms of Common Poisons, Types of antidotes,3.2Examination and grouping of blood strains and seminal strains, 3.3 Data Retrieval and automation techniques for forensic examination concerningthe presence of drugs, glasses, paints, oils and adhesives at crime spot, 3.4Detection of poisoning in the Dead. Selection, Collection and Preservation of Viscera for various Types of Poisons: Choice of Preservatives, Containers and Storage3.5Different Methods of Extraction, Isolation, Identification, Estimation of Poisons from Biological Specimens

Module IV: Forensic Toxicology 15 hours

4.1 Role of the Toxicologist, Significance of Toxicological findings, Poisons, definition, 4.2 Classification based on their Origin, Physiological Action and Chemical Nature,4.3 Analysis of various types of poisons (corrosive, irritant, analgesic, hypnotic, tranquilizer, narcotic, stimulants, paralytic, anti-histamine, domestic and industrial4.4 Explosive and explosion residue analysis,4.5 Lethal drug analysis, Drug Abuse in Sports: Introduction, Common prohibited substances, Analytical approach, 4.6Importance of physiological tests in forensic toxicology, 4.7 Analysis of Fire Scene Evidence, Instrumental Methods for Fire Debris Analysis. Analysis of Petroleum Products in Adulterant Cases.

References

1. Curry, A.S. Advances in Forensic Chemical Toxicology. CRC Press:(1972).
2. Curry, A.S. Analytical Methods in Human Toxicology: Part II. Wiley VCH:(1986).
3. Gosselin, R.E.; Hodge, H.; Smith, R.P. and Gleason, M.N. Clinical Toxicology of Commercial Products: Acute Poisoning 4th ed. Williams & Wilkins: Baltimore; (1969).
4. Lundquist, F. and Curry, A.S. Methods of Forensic Science. Inderscience Publisher: California; (1963)
5. Maehly, A. and Stromberg, L. Chemical Criminalistics. Springer: New York; (2011).
6. Matsumura, F. Toxicology of Insecticides. Springer: New York; (1985).

Teaching Learning Strategies

- Provide updated Lecture Sessions
- Promote Interactive Sessions including discussions and demonstrations.
- Provide experiments to engage students actively and visual aids like presentations, videos, and models to enhance understanding.
- Encourage students to ask questions during or after the lectures

MODE OF TRANSACTION

• Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes.

1. What is the primary goal of forensic science?
2. What is the difference between circumstantial and direct evidence?
3. Explain the use of instruments in forensic analysis
4. Discus the effect of toxicology in forensic analysis

DISCIPLINE SPECIFIC ELECTIVE (DSE)

CATALYSIS, KINETICS AND SOLUTION CHEMISTRY

Course Title	:	**Catalysis, Kinetics and Solution Chemistry**
Course Code	:	**KU08DSECHE410**
Course Type	:	**DSE**
Course credit	:	**4**
Prerequisites	:	**Fundamental concepts in Thermodynamics and Chemical kinetics**

Course Objectives:

- To introduce the students to the basic and advanced concepts of catalysis, kinetics, and solution chemistry.
- To give them a brief idea of the advanced techniques like photocatalysis, and kinetics in the excited state.

Credits			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

Course Outcomes:

CO1	**Understand** and **Apply** basic concepts and recent development in catalysis.

CO2	**Solve** problems on rate/rate constants/efficiency for (i) complex reactions and (ii) electronically excited state dynamics.
CO3	**Plot** equations and functions representing kinetic behaviour of chemical systems in ground and electronically excited states.
CO4	**Apply** the ideas from thermodynamics for the description of solution state properties.
CO5	**Apply** theories in kinetics, catalysis and solutions in real scenarios in laboratory.

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	3	3	2	3	3	3	3	2	2
CO2	3	3	3	3	3	3	3	3	2	3	2	2
CO3	3	3	3	3	3	3	3	3	2	3	2	2
CO4	3	3	3	3	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3	3	3

Module 1: Catalysis at a glance **15 hours**

Fundamentals: Catalyst - activation energy concept - homogeneous & heterogeneous catalysis, enzyme catalysis, green catalysis, nano catalysis, autocatalysis, phase transfer catalysis, promoters, poisons - examples.

Photocatalysis: Porphyrins -phthalocyanines and semiconductor as photo catalysts in photolysis reactions, generation of hydrogen by photo catalysts, photocatalytic break down of water and harnessing solar energy, photocatalytic degradation of dyes, environmental applications.

Module 2: Comprehensive catalysis **15 hours**

Homogeneous catalysis: Noyori asymmetric hydrogenation, metal mediated C-C and C-X coupling reactions, Heck, Stille, Suzuki, Negishiand Sonogashira, Nozaki-Hiyama, Buchwald-Hartwig, Ullmann coupling reactions, directed orthometalation - metal (Rh, Ir) catalyzed C-H activation reactions and their synthetic utility.

Heterogeneous catalysis: porous solids, catalysis by metals, semiconductors and solid acids, supported metal catalysts, catalyst preparation, deactivation and regeneration, model catalysts, ammonia synthesis, hydrogenation of carbon monoxide, selective catalytic reduction, polymerization.

Module 3: Kinetics of reactions in solution **15 hours**

Diffusion controlled reactions, kinetic salt effect, kinetic isotope effects, factors determining reaction rates in solution- solvent dielectric constant and ionic strength, Dynamics of barrier-less chemical reactions in solutions, Effect of pressure on velocity of gas reactions.

Chain reactions - linear reactions, branching chains - explosion limits; Rice–Herzfeld scheme; kinetics of free radical polymerization reactions. Enzyme catalysis - rates of enzyme catalysed reactions - effect of substrate concentration, pH and temperature - determination of Michael's parameters.
Kinetics in the excited state: Jablonski diagram, Kinetics of Unimolecular andbimolecular photophysical and photochemical processes, Quantum yield calculation,Excited state lifetime-quenching constant, Resonance energy transfer rates (RET),Rate and efficiency of RET, Dynamics of electron transfer, Solvent re-organizationenergy, Marcus theory of electron transfer, Free energy and rate relation, Rehm-Weller behaviour, Marcus Inverted Region

Module 4: Solution Chemistry **15 hours**
Solution composition, ways of expressing concentration, molarity, molality, normality, mole fraction, solutions of gases in gases, Henry's law, solutions of liquids in liquids, solubility of completely miscible liquids, solubility of partially miscible liquids, phenol-water system,nicotine-water system, vapour pressures of liquid-liquid mixtures, azeotropes, theory offractional distillation, steam distillation, solutions of solids in liquids, solubility-equilibrium concept, determination of solubility, solubility of solids in solids.

Reference

1 P. Atkins, J. de Paula and J. Keeler, Atkins' Physical Chemistry, 11th Ed., Oxford University Press, 2018.
2. P. H. Emmet, Catalysis (Vol I and II), Reinhold, 1954.
3. D. K. Chakrabarty and B. Viswanathan, Heterogeneous Catalysis, New Age, 2008.
4. K. J. Laidler, Chemical kinetics, 3rd edn., Pearson education, 2004.
5. B. R. Puri, L. R. Sharma, M. S. Pathania, Principles Of Physical Chemistry 46th Edition, Vishal Publishing Company, New Delhi, 2013.

Teaching Learning Strategies
- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting Active learning

Mode of Transactions
- Lectures, seminars, discussions, and demonstrations.
-

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminars	10	
	Viva	10	

Sample Questions to test Outcomes
1. Give an account on phase transfer catalysis.
2. Discuss Heterogeneous catalysis with suitable examples.
3. Discuss the mechanism and kinetics of enzyme catalyzed reactions.
4. Draw phase diagram for phenol-water system. Label the regions and intersections of the diagram, stating what materials are present and whether they are solid, liquid, or gas.

DISCIPLINE SPECIFIC ELECTIVE (DSE)
INSTRUMENTATION TECHNIQUES

Course Title	**:**	**INSTRUMENTATION TECHNIQUES**
Course Code	**:**	**KU08DSECHE411**
Course Type	**:**	**DSE**
Course credit	**:**	**4**
Prerequisites	**:**	**Fundamental concepts in instrumentation techniques**

Course Objectives:

- To introduce the students to the basic and advanced concepts of instrumentation techniques
- To give them a brief idea of the advanced techniques SEM and AFM

Credits			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

Course Outcomes:

CO1	**Understand** and **Apply** basic concepts and recent molecular analysis
CO2	**Solve** problems on atomic surface Techniques
CO3	**Understand** and **Apply** basic concepts and radiochemical procecss
CO4	To apply modern instrumentation techniques in analysis of samples

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	3	3	2	3	3	3	3	2	2
CO2	3	3	3	3	3	3	3	3	2	3	2	2
CO3	3	3	3	3	3	3	3	3	2	3	2	2
CO4	3	3	3	3	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3	3	3

UNIT – I Molecular Spectral Analysis **15 hours**

Introduction to instrumental methods, selection of instrumental methods: precision, sensitivity, selectivity, and detection limit. Sources of noise and S/N ratio.Fundamental law of spectrophotometry, nephelometry and turbidometry and Fluorimetry.UV-visible and IR spectrophotometry – instrumentation, single and double beam instruments, Spectrophotometric titrations. Introduction to NMR spectroscopy: magnets, shim coils, sample spinning, sample probes (^{1}H, ^{13}C, ^{31}P).

UNIT – II Atomic and Surface Techniques **15 hours**

Atomic emission spectrometry – excitation sources (flame, AC and DC arc), spark, inductively coupled plasma, glue discharge, laser microprobes, flame structure, instrumentation, and qualitative and quantitative analysis. Atomic absorption spectrometry: sample atomization techniques, instrumentation, interferences, background correction, and analytical applications. Atomic fluorescence spectrometry – theory, instrumentation and applications. Instrumentation of X-ray methods: X-ray absorption and X-ray diffraction. Photoelectron spectroscopy.XPS, UPS. Auger, ESCA. SEM, TEM, AFM, STM.

Unit-III Thermal and Radiochemical Methods **15 hours**

Thermogravimetry (TG), Differential Thermal Analysis (DTA), and Differential Scanning Calorimetry (DSC), and their instrumentation.Thermometric Titrations.Measurement of alpha, beta, and gamma radiations, neutron activation analysis and its applications.Principle and applications of isotope dilution methods. Radiation dosimetry – Fricks dosimetrycalculation of absorbed dose.

UNIT – V Modern Techniques in Analytical Chemistry **15 hours**

Hyphenated techniques – Gas Chromatography – Mass Spectrometry (GC-MS), Liquid Chromatography – Mass Spectrometry (LC-MS), Gas Chromatography/Liquid Chromatography-Infrared Spectroscopy (GC/LC-IR), Liquid Chromatography-Nuclear Magnetic Resonance Spectroscopy (LC-NMR), Tandem Mass Spectrometry (MS/MS) techniques, Flow injection analysis (FIA).

References

1. D. A. Skoog, D. M. West, F.J. Holler, S.R. Crouch, Fundamentals of Analytical Chemistry, 8th Edn., Saunders College Pub., 2007.
2. J.H. Kennedy, Analytical Chemistry: Principles, Saunders College Pub. 1990.
3. G.H. Jeffery, J. Bassett, J. Mendham, R.C. Denney, Vogel's Textbook of Quantitative Chemical Analysis, 5th Edn., John Wiley& sons,1989.
4. G. D. Christian, Analytical Chemistry, 6th ed., John Wiley & Sons, 2007.
5. R.A. Day, A.L. Underwood, Quantitative Analysis, Prentice Hall, 1967.
6. A.I. Vogel, A Textbook of Practical Organic Chemistry, Longman,1974.
7. H.A. Laitinen, W.E. Harris, Chemical Analysis, McGraw Hill,1975.
8. V.K. Ahluwalia, Green Chemistry: Environmentally Benign Reactions, CRC,2008.
9. F.W. Fifield, D. Kealey, Principles and Practice of Analytical Chemistry, BlackwellScience, 2000.

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting Active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.
-

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminars	10	
	Viva	10	

DISCIPLINE SPECIFIC ELECTIVE (DSE)

COMPUTATIONAL CHEMISTRY

Course Title : COMPUTATIONAL CHEMISTRY

Course Code : **KU08DSECHE412**
Course Type : **DSE**
Course credit : **4**
Prerequisites : **Basics of quantum mechanics of simple and complex systems**

Course Objectives:

- To provide an idea about the history and development of quantum mechanics
- To provide the mathematical techniques of quantum chemistry
- To illustrate the methods of applications of quantum mechanics to simple systems
- To illustrate the methods of applications of quantum mechanics to chemical systems

Course Outcomes

CO1	Learn the history and development of Quantum chemistry
CO2	Acquire knowledge about the nuances of particle in box problem
CO3	Application of quantum mechanics to harmonic oscilator
CO4	Deducing and applying quantum mechanics to rigid rotor.

Mapping of Course Outcome to POs/PSOs

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**
CO 1	3	3	3	3	2	3	3	2	2	2	1	1
CO 2	3	3	2	2	2	3	2	1	2	2	1	1
CO 3	2	3	3	2	2	1	1	2	2	2	2	1
CO4	1	3	3	1	1	3	2	3	2	2	1	1

Unit 1 Many electron atoms **15 Marks**

Electron correlation, addition of angular momentum, Clebesch-Gordan series, total angular momentum and spin-orbit interaction.

Unit II Ab Initio Methods **15 Hours**

Review of molecular structure calculations, Hartree-Fock SCF method for molecules, Roothaan-Hartree-Fock method, selection of basis sets.

Unit III Electron Correlation and Basis Sets 15 Hours

Configuration Interaction, Multi-Configuration Self Consistent Field, Multi-Reference Configuration Interaction, Many-Body Perturbation Theory, Coupled Cluster, Basis sets.

Unit IV DFT and Force Fields method 15 Hours

Energy as a functional of charge density, Kohn-Sham equations. Molecular mechanics methods, minimization methods, QSAR.

References

1. Introduction to Computational Chemistry, F. Jensen, 2nd edition, Wiley-Blackwell (2006).
2. Molecular Quantum Mechanics, P. W. Atkins and R. S. Friedman, 3rd edition, Oxford University Press, Oxford (1997).
3. Quantum Chemistry, H. Eyring, J. Walter and G.E. Kimball, (1944) John Wiley, New York.
4. Quantum Chemistry, I.N. Levine, 5th edition (2000), Pearson Educ., Inc., New Delhi.
5. Modern Quantum Chemistry: Introduction to Advanced Electronic Structure, A. Szabo and N. S. Ostlund, (1982), Dover, New York.
6. Cramer, C. J. Essentials of computational Chemistry: Theories and models, 2nd Ed., John Wiley & Sons, 2004.
7. Levine, I. N. Quantum Chemistry, 7th Ed., Pearson, 2013.
8. Wilson, E. B., Decius, J. C. and Cross, P. C. Molecular Vibrations: The Theory of Infrared and Raman Vibrational Spectra, Dover, New York, 1980

Teaching Learning Strategies

- Introducing the concept of the subject
- Providing knowledge about the subject
- Transferring the know-how with examples
- Illustrating the application of the titled course to the society

Mode of Transactions

• Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Describe how electron correlation affects the total angular momentum in a multi-electron system. How does the addition of angular momenta (both orbital and spin) affect the energy levels of atoms, and how is the Clebesch-Gordan series used in this context?
2. Explain Heisenberg Uncertainty principle
3. Explain the concept of spin-orbit interaction and how it leads to the splitting of atomic energy levels.
4. What are the key advantages of using MCSCF over CI in describing systems with significant electron correlation? Provide an example where MCSCF would be more appropriate than CI.

DISCIPLINE SPECIFIC ELECTIVE (DSE)
CERAMICS AND COMPOSITE MATERIALS

Course Title	:	**CERAMICS AND COMPOSITE MATERIALS**
Course Code	:	**KU08DSECHE413**
Course Type	:	**DSE**
Course credit	:	**4**
Prerequisites	:	**Basics Material Chemistry**

Course Objectives	
1.	To introduce the different types of ceramics and composite materials, their properties and applications.

2.	To introduce the special characteristics and fabrication methods of different classes of ceramics.
3.	To impart knowledge on structure and electrical, magnetic, optical, mechanical and thermal properties of ceramic materials.
4.	To introduce mechanical response of composite materials and to use this information in simple examples of design.

Credit			Teaching Hours			Assessment		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
3	0	3	54	0	54	40	60	100

Course Learning Outcomes:

C01	Identify type of bonding present, types of crystal structure, and expected mechanical responses in a ceramic material.
C02	Acquire knowledge of properties of ceramics and their structural origin
C03	Identify the stress-strain response of ceramics and composites and know generally how these are altered by strengthening/hardening mechanisms, etc.
C04	Acquire knowledge about the properties and applications of ceramic matrix composites, polymer matrix composites and metal matrix composite
C05	Identify type of bonding, structure, chemical modifications and applications of inorganic polymers

Unit-I Ceramics –I **15 Hours**

Introduction, bonding, structure and its effects on physical properties, thermodynamics and kinetic considerations, sintering, defects of ceramics, diffusion Phase equilibria in ceramic systems (one component, binary and ternary systems), chemical reactions at high temperatures and processing of ceramics Thermal properties of ceramics, high temperature materials. Mechanical properties, creep, fatigue, crack growth, electrical conductivity Magnetic properties, Hysteresis curves, magnetic ceramics and their applications, optical properties, scattering, opacity.

Unit-II Ceramics –II **15 Hours**

Crystalline ceramic materials: oxide, carbide, nitride, graphite and clay materials and their structures. Polymorphism, non-crystalline ceramic materials: structure and structural requirements for stability, mode of formation Silicate and nonsilicate glasses, hydrogen bonded structures, applications. Ceramic glasses and their applications, Introduction to bio-ceramic materials and their applications.

Unit-III Composites **15 Hours**

Introduction, classification of composites according to the matrix, classification of composites according to the reinforcement Synthesis techniques, properties and applications of ceramic matrix composites, polymer matrix composites and metal matrix composites Composite Strengths: dispersion and particulate strengthened composites. Fibers as reinforcements. Composite Interfaces, Bonding Mechanisms, other Interfacial properties

Unit-IV Inorganic Polymers **15 Hours**

Polyphosphazenes: Introduction, classification, bonding, synthetic routes, characterization, and biomedical applications Organosilicon polymers: polysiloxane preparation, structure and applications Synthesis and chemical modification of polysilanes, application of polysilanes as photoresists and photoinitiators Organometallic polymers: Introduction, structure & bonding, synthetic routes, and applications.

References

1. Elements of Ceramics, F.H. Norton.
2. Introduction to ceramics, W.D. Kingery, H.K. Dowen and R.D. Uhlman, John Wiley.
3. Fundamentals of Ceramics, M.W. Barsoum, McGraw Hill.
4. Introduction to Materials Science and Engineering, William J Callister, John Wiley & Sons Inc.
5. Introduction to Materials Science and Engineering, William J Callister, John Wiley & Sons, Inc.
6. Introduction to the Principles of Ceramic Processing, J. S. Read, Wiley-Interscience Fundamentals of Ceramics, M.W. Barsoum, McGraw Hill.
7. Material Science and Engineering, S.K. Hajra Choudhury, Indian Book Dist.
8. Introduction to Materials Science and Engineering, William J Callister, John Wiley & Sons, Inc.
9. Composite Materials: Engineering and Science - F. L. Matthews and R. D. Rawlings, Chapman & Hall.
10. Advanced Composite Manufacturing - Gutowski, Wiley Inorganic and organometallic polymers, Chandrasekhar V .Springer.
11. Introduction to polymers, Young and Lowell, Viva Publications

12. Contemporary polymer chemistry, Allcock, Lampe and Marle, Pearson education
13. Inorganic polymers, Mark J E, Allcock HR, West R. Oxford University Press, New York
14. Inorganic and organometallic polymers, Chandrasekhar V .Springer.

Sample Questions to test Outcomes

1. Explain Ferromagnetic ceramics with suitable hysteresis curves.
2. Write short notes on Perovskite structure and Corundum structure with examples
3. Explain the phase equilibria in one component, binary and ternary ceramic systems
4. Discuss about the applications of polysilanes as photoresistors and photoinhibitors.
5. Explain the hot-pressing method used for the production of whisker reinforced composites.

DISCIPLINE SPECIFIC ELECTIVE (DSE)
ANALYTICAL CHEMISTRY

Course Title	:	**ANALYTICAL CHEMISTRY**
Course Code	:	**KU08DSECHE414**
Course Type	:	**DSE**
Course credit	:	**4**
Prerequisites	:	**Solution chemistry, Basic Instrumentation**

Course Objectives:

- To develop an understanding of the range and uses of analytical methods in chemistry.
- To establish an appreciation of the role of chemistry in quantitative analysis.
- To develop an understanding of the broad role of the chemist in measurement and problem solving for analytical tasks.
- To provide an understanding of different characterization techniques employed for

elemental and compound analysis.

Credit			Teaching Hours			Assessment		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
4	0	4	4	0	4	50	50	100

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	The student learns the skill to prepare standard solution, samples and analysis of the samples through using accurate methods. The course makes the student to learn how to prepare solutions quantitatively and analysis the analyte with high accuracy.
C02	Apply the knowledge of chromatography to separates the constituents from a complex mixture.
C03	Students will learn physical, chemical and biological characterization methods
C04	Students will learn in detail about X-ray diffractometry, Scanning probe microscopy and scanning tunneling microscopy, Optical microscopy– SEM, TEM, AFM, UV-Vis-NIR spectrometry and FTIR

Mapping of Course Outcomes to POs/PSOs:

	PSO 1	PSO 2	PSO 3	PSO 4	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
C0 1	3	3	2	2	2	3	1	2	1	3	1	3
C0 2	3	3	2	2	2	3	1	2	1	3	1	3
C0 3	3	3	2	2	1	2	1	2	1	3	1	3
C0 4	3	3	2	2	1	2	1	2	1	3	1	3

Module I: Introduction to analytical methods 15 hours

1.1.Introduction to analytical and instrumental methods,1.2.classification of analytical techniques,1.3.Precipitation phenomena, 1.4.organic precipitants in inorganic analysis,1.5.Extraction of metal ions, 1.6.nature and types of extractants and its applications, 1.7.chelometric titration, 1.8.Masking and de masking techniques, 1.9.industrial applications of masking. 1.10.Separation techniques: 1.11.Solvent extraction, 1.12.batch and continuous extractions, extraction of metal ions, 1.13.nature and types of extractants and its applications.

Module II: Chromatography and Electroanalytical methods 15 hour

2.1.Introduction to chromatography, 2.2.classification of chromatographic methods,2.3.theory, techniques and applications.

2.4.Radio analytical methods: Introduction, principle and application of neutron activation analysis (NAA), 2.5.isotope dilution analysis and radiometric titrations. 2.6.Electro analytical methods:Principles and applications of Voltammetry, 2.7.Cyclic voltammetry (CV), 2.8.Polarography, 2.9.Stripping voltammetry, 2.10.Conductometry, 2.11.Amperometry, 2.12.Potentiometry and Electrogravimetry.

Module III: Spectroscopy and microscopy methods of analysis 15 hours

3.1.Introduction to instrumentation, 3.2.method of samplings, data analysis and applications to chemistry of the followings, 3.3.Attenuated Total Reflection Spectroscopy, 3.4.Electronic Spectroscopy for Chemical Analysis (X-ray Photo Electron Spectroscopy),3.5.UV-Photo Electron Spectroscopy.3.6.Ion Scattering Spectroscopy, 3.7.Secondary Ion Mass Spectroscopy, 3.8.Auger Electron Spectroscopy

3.9.Principles, general instrumentation and applications of Scanning Electron Microscopy, 3.10.Scanning Tunneling Electron Microscopy, 3.11.Atomic Absorption Spectroscopy and Instrumentations of NMR, 3.12.IR, UV-Visible and Mass spectrometry.

Module IV: Instrumental methods of analysis 15 hours

4.1.Principles, instrumentation and applications of thermogravimetry (TGA-DTA), 4.2.Differential Scanning Calorimetry, 4.3.Dynamic Mechanical Analyzer, Dynamic Chemical Analyzer, 4.4.Direct injection enthalpymetry and thermometric titrimetry,

4.5.Principles, instrumentation and applications of Fluorimetry, 4.6.Phosphorimetry, 4.7.Flame photometry, 4.8.Nephelometry and Turbidimetry.

Reference Books

1. Principles of quantitative chemical analysis, de Levine, McGraw Hill.

2. Vogel's Qualiitative Inorganic Analysis, Pearson Education
3. Vogel's Quantitative chemical analysis, Pearson Education
4. Fundamentals of Analytical Chemistry, Skoog, West, Holler, Croach, Thomson Brooks/Cole
5. Instrumental methods of chemical analysis, Willard, Dean and Merrit, Affiliated East West Press
6. Modern analytical chemistry, Harvey, McGraw Hill
7. Principles and practice of Analytical Chemistry, F.W. Fifield and D. Kealeg, Blackwell publications

Teaching Learning Strategies

- Provide updated Lecture Sessions
- Promote Interactive Sessions including discussions and demonstrations.
- Provide experiments to engage students actively and visual aids like presentations,
- Videos and models to enhance understanding.
- Encourage students to ask questions during or after the lectures

Mode of Transaction

- Lectures, seminars, discussions, and demonstrations.

ASSESSMENT RUBRICS			Total
End Semester Evaluation	External Exam	50	50
Continuous Evaluation	Internal Exam	20	50
	Assignment	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Explain the principle of HPLC?
2. Define the terms elution and eluent?
3. How is paper partition chromatography different from paper adsorption chromatography?
4. Explain the significance of Rf value in chromatographic separation?
5. What is NAA? Give any one use of this technique.

DISCIPLINE SPECIFIC ELECTIVE (DSE)

ADVANCED ELECTROCHEMISTRY

Course Title	:	**ADVANCED ELECTROCHEMITRY**
Course Code	:	**KU08DSECHE415**
Course Type	:	**DSE**
Course credit	:	**4**
Prerequisites	:	**Solution chemistry, Basic Instrumentation**

Course Objectives:

1. To develop an understanding of non-ideality of electrolyte solutions and its effect on equilibrium constants, electrolyte solutions and solution conductivity.
2. Learn about the thermodynamics of electrochemistry, the structure of the electrode/electrolyte interface and electrode processes.
3. To know about the phase rule and its application in 3 component system.
4. Defines phase, equilibrium, component, degree of freedom and phase rule concepts.

Credit			Teaching Hours			Assessment		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
3	0	3	54	0	54	40	60	100

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	To understand theories of electrolytes and electrochemical reactions.Ascertain the application of electrochemistry in industrial fields.
C02	Understand the theories and applications behind various types of analytical techniques in electrochemistry. Describe the reactions occurring in an electrochemical (voltaic) cell

C03	Acquire the knowledge in Phase composition and rule, Understand the significance of electrochemistry, how it relates to other fields of science, and how it is applied in real life
C04	Acquire skill in solving numerical problems. Defines the importance of Phase Diagrams in the field of materials science. Explains the basic definitions and terms in a phase diagram.

Mapping of Course Outcomes to POs/PSOs:

	PSO 1	PSO 2	PSO 3	PSO 4	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
C0 1	3	3	2	2	2	3	1	2	1	3	1	3
C0 2	3	3	2	2	2	3	1	2	1	3	1	3
C0 3	3	3	2	2	1	2	1	2	1	3	1	3
C0 4	3	3	2	2	1	2	1	2	1	3	1	3

UNIT I – Ionics-I **15 Hours**

Characteristics of ionics and electrodics, properties of materials and surfaces, Ionics: Ionsolvent interaction, structure of water, ion- dipole model and ion -solvent interaction, dielectric effects and dielectric constants of solution, ion- dipole model and ion-solvent interaction, Dielectric effects and dielectric constants of solution, ion -quadrupole model of ion – solvent interaction, Ion – ion interaction, Debye-Huckel ion cloud theory, Linearized Poisson – Boltzmann equation and its solution, Activity coefficient and ion – ion interaction, ion cloud and chemical potential change, activity, activity coefficient and ion -ion interaction, and ion - solvent interaction, merits and demerits of Debye- Huckel theory of activity coefficient, Debye- Huckel Limiting Law.

Unit II Ionics-II **15 Hours**

Ionic diffusion under chemical potential gradient, Fick's law, diffusion coefficient, random walking model, Einstein- Smoluchowski's equation, ionic drift under electric field, quantitative link between electron flow and ion flow in electrolytes – Faraday's law, electric field and current density,, ionic migration, Einstein relation between absolute mobility and diffusion coefficient,, Nernst- Einstein relation, stoke's - Einstein relation, Interdependence of ionic drift, diffusion potential, Onsagar phenomenological equation, Debye – Huckel -Onsagar equation, Changes to Debye – Huckel – Onsagar equation.

Unit III Electrodics **15 Hours**

Overview of reversible electrode processes, electrochemical cells and reactions, Faradaic and non - Faradaic processes, Nature of electrode - solution interface, ideal polarized electrode, capacitance and charge of an electrode, Electrical Double Layer and theories of EDL, thermodynamics of double layer, surface excess and electro capillary equation, Double layer capacitance and charging current, Faradaic process and factors affecting rates of electrode reaction, mass transfer controlled reactions – modes of mass transfer, Kinetics of electrode reaction, relation between reaction rate, current and potential, current - potential diagram, Butler -Volmer model of electrode kinetics, Polarization phenomena and over potential, Over potentials in electrolysis, Dependence of the Electrochemical Reaction Rate on Overpotential, Butler Volmer Equation & Tafel equation and Tafel plot. Solid state electrochemistry-Ion conducting polymers, electronically conducting polymers and redox polymers.

UNIT – IV Electrochemical Techniques **15 Hours**

Electrochemical Techniques: Basic Potential step and potential sweep methods, Potentiometry, Voltammetry : Polarography, Pulse Voltammetry, Cyclic Voltammetry (detailed description), Anode Stripping Voltammetry, Hydrodynamic Voltammetry, Chronopotentiometry, Amperometry, Chrono amperometry , Coulommetry, Chrono coulometry, Spectroelectrochemistry. Electrochemical impedance and its application.

References

1. Bockris and Reddy - Modern Aspects and Electrochemistry vol. I and II, Academic Press. P.W. Atkins - Physical Chemistry, ELBS Oxford University Press.
2. Allen J Bard and Larry R Faijlkner, Electrochemical Methods – Fundamentals & Applications.
3. S. Glasstone - Introduction to Electrochemistry, Van Nonstrand
4. Skoog and West - Fundamentals of Analytical Chemistry.
5. Joseph Wang - Analytical Electrochemistry.
6. J.O.M. Bokris and A.K.N. Reddy, Modern Electrochemistry,PlenumPress, 1973.
7. Modern Electrochemistry, J.O.M. Bockris and A.K.N. Reddy, Plenum
8. Physical Chemistry, Daniels and Alberty, John Wiley.

Teaching Learning Strategies

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- Videos and models to enhance understanding.
- Encourage students to ask questions during or after the lectures

Mode of Transaction

- Lectures, seminars, discussions, and demonstrations.

ASSESSMENT RUBRICS			Total
End Semester Evaluation	External Exam	50	50
Continuous Evaluation	Internal Exam	20	50
	Assignment	10	
	Seminar	10	
	Viva	10	

SEMESTER IX

DISCIPLINE SPECIFIC CORE (DSC)
SPECTROSCOPY II

Course Title	:	**SPECTROSCOPY II**
Course Code	:	**KU09DSCCHE416**
Course Type	:	**DSC**
Course Credits	:	**4**
Pre-requisites	:	**Basic organic concepts, Fundamentals of analytical and instrumentation techniques**

Course Objectives

5. To understand the basic principle, instrumentation and applications ofIR spectroscopy
6. To learn the basic principle, instrumentation and applications ofRaman spectroscopy
7. To learn the basic principle, instrumentation and applications ofESR and NMR spectroscopy
8. To learn the basic principle, instrumentation and applications of Mossbauer, XPS and Mass Spectroscopy

Credit			Teaching Hours			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	60	0	60	50	50	100

Course Outcome

CO1	Acquire knowledge onprinciple, instrumentation and applications of IR spectroscopy
CO2	Explain the principle, instrumentation and applications of Raman spectroscopy
CO3	Acquire knowledge on principle, instrumentation and applications of NMR and ESR
CO4	Explain the basic principle, instrumentation and applications of Mossbauer, XPS and Mass Spectroscopy
CO5	Elucidate the structure of an unknown organic compound usingdata from various spectroscopic techniques

Mapping of course Outcomes with POs/PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	3	3	3	3	3	2	2	2	3	1	2
CO 2	3	3	2	2	3	3	2	2	2	3	1	2
CO 3	2	3	3	2	3	3	2	2	2	3	1	2

CO 4	**1**	**3**	**3**	**1**	**3**	**3**	**2**	**2**	**2**	**3**	**1**	**2**
CO 5	**3**	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**3**	**1**	**2**

Module I: IR Spectroscopy **15 hrs**

1.1 Introduction to vibrational spectroscopy, harmonic oscillator: calculation of force constant and energy levels, 1.2 Concept of anharmonicity: Morse potential and dissociation energies. 1.3 Vibrational energy of diatomic molecules: simple harmonic and anharmonic oscillators, 1.4 Diatomic vibrating rotator, vibration rotational spectrum ofc carbon monoxide, 1.5 Vibrational spectrum of polyatomic molecules, 1.6 Fundamental vibrational and their symmetry,1.7 Overtones, hot bands, fermi resonance, 1.8 Influence of rotation on the vibrational spectra of polyatomic linear andpolyatomic symmetric top molecules, parallel and perpendicular vibrations,1.9 Chemical analysis by infrared spectroscopy.

Module II: Raman Spectroscopy **15 hrs**

2.1 Introduction to Rama spectroscopy, scattering of light, polarizability, 2.2 Classical theory of Raman spectrum, 2.3 Quantum theory of Raman effect, 2.4 Pure rotational Raman spectra of linear and symmetric top molecules, 2.5 Vibrational Raman spectra: Raman activity of vibrations, 2.6 Stokes and anti-Stokes lines: their intensitydifference, 2.7 Rule of mutual exclusion, 2.8 Overtones and combination vibrations, 2.9 Rotational fine structure, 2.10 Vibrations of spherical top molecules, 2.11 Applicationsof Raman spectroscopy.

ModuleIII: NMR and ESR Spectroscopy **15 hrs**

3.1 Magnetic properties of nuclei, theory and measurement techniques, population of energy levels, 3.2 Chemical shift and its measurement, factors affecting chemical shift, 3.3 Relaxation methods, integration of NMR signals, 3.4 Spin-spin coupling, coupling constant 'j' and factors affecting it, 3.5 Shielding and de-shielding, 3.6 Chemicalshift assignment of major functional groups, spin decoupling, 3.7 NMR studies of nuclei otherthan Proton: ^{13}C, ^{19}F and ^{31}P NMR. 3.8 ESR spectroscopy: electron spin in molecules, interaction with magnetic field, 'g' factor, factors affecting'g' values, 3.9 Fine structure and hyperfine structure, Kramers' degeneracy, 3.10 Applications of ESR spectroscopy.

ModuleIV: **Mossbauer, XPSand Mass Spectroscopy** **15 hrs**

4.1 Mossbauer Spectroscopy: Principle, Doppler effect, recordingof spectrum, 4.2 Chemical shift, factors determining chemical shift, 4.3 Application for the analysis of metal complexes.4.4 X-ray spectroscopy: origin of X-ray spectra, 4.5 Moseley's law, X-ray fluorescence, 4.6 Basicprinciples of energy dispersive X-ray spectrometry (XPS), instrumentation andapplications of XPS.4.7 Mass spectroscopy: basic principles, ionization methods;gas phaseionization methods,desorption ionization methods and plasma desorption ionization. 4.8 Separationtechniques - time of flight analyser and quadrupole mass analyser, 4.9 Types of peaks involved, fragmentation pathways, 4.10 Applications of mass spectrometry.

References

1. Banwell, C. N. &Mc Cash, E. M. Fundamentals of Molecular Spectroscopy,4th Ed. Tata McGraw-Hill: New Delhi (2006).
2. D.L. Pavia, G.M. Lampman, G.S. Kriz, Introduction to Spectroscopy, 3rd Edn., Brooks Cole, 2000
3. A.U. Rahman, M.I. Choudhary, Solving Problems with NMR Spectroscopy, Academic Press, 1996.
4. L. D. Field, S. Sternhell, J. R. Kalman, Organic Structures from Spectra, 4th Edn., John Wiley & sons, 2007.
5. D.F. Taber, Organic Spectroscopic Structure Determination: A Problem Based Learning Approach, Oxford University Press, 2007.
6. H. Gunther, NMR Spectroscopy, 2nd Edn., Wiley, 1995.
7. E.B. Wilson Jr., J.C. Decius, P.C. Cross, Molecular Vibrations: The Theory of Infrared and Raman Vibrational Spectra, Dover Pub., 1980
8. T. Engel, Quantum Chemistry and Spectroscopy, Pearson Education, 2006
9. K.Veera Reddy, Symmetry and Spectroscopy of molecules, New Age International (P) Ltd,1999.
10. Ewen Smith, Geoffrey Dent, Modern Raman Spectroscopy: A Practical Approach, John Wiley & Sons Ltd., 2019
11. Barbara H. Stuart, Infrared Spectroscopy: Fundamentals and Applications, John Wiley & Sons Ltd., 2004
12. Roger S Macomber, A complete introduction to modern NMR spectroscopy, Wiley, 1997
13. Anders Lund, Masaru Shiotani, Shigetaka Shimada, Principles and Applications of ESR Spectroscopy, Springer, 2011
14. Yutaka Yoshida, Guido Langouche, Mössbauer Spectroscopy, Springer, 2013
15. Jürgen H Gross, Mass Spectrometry, Springer Science & Business Media, 2022

16. Arpana Agrawal,X-Ray Photoelectron Spectroscopy: Principles, Techniques and Applications, Nova Science Publishers, 2023

Teaching Learning Strategies

- Provide updated Lecture Sessions
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- Provide experiments to engage students actively and visual aids like presentations, videos, and models to enhance understanding.
- Encourage students to ask questions during or after the lectures

Mode of Transaction

- Lectures, seminars, discussions, and demonstrations

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Write a short note on Morse potential and dissociation energy.
2. Explain the classical theory of Raman spectrum.
3. What are the factors affecting chemical shift in NMR?
4. Explain the basic principle of energy dispersive X-ray spectrometry.
5. Why Stokes lines are more intense than anti-Stokes lines in Raman spectroscopy?

DISCIPLINE SPECIFIC CORE (DSC)
THEORETICAL CHEMISTRY-II

Course Title	:	**THEORETICAL CHEMISTRY-II**
Course Code	:	**KU09DSCCHE417**
Course Type	:	**DSC**
Course credit	:	**4**
Prerequisites	:	**Brief idea about fundamental of quantum chemistry**

Course Objectives:

- To provide an idea about solving hydrogen atom
- To provide the mathematical techniques of approximation techniques
- To illustrate the methods of applications self consistent field approximations
- To illustrate the methods of applications of quantum mechanics to chemical systems

Course Outcomes

CO1	Learn the solution of hydrogen atom
CO2	Acquire knowledge about approximation methods
CO3	Application of self consistent field approximations
CO4	Deducing and applying quantum mechanics to chemical bonding

Mapping of Course Outcome to POs/PSOs

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**
CO 1	3	3	3	3	2	3	3	2	2	2	1	1
CO 2	3	3	2	2	2	3	2	1	2	2	1	1
CO 3	2	3	3	2	2	1	1	2	2	2	2	1
CO4	1	3	3	1	1	3	2	3	2	2	1	1

Unit –I Quantum Mechanics of Hydrogen Like atom **15 hours**

Hamiltonian operator and Schrödinger equation for Hydrogen-like atoms in spherical polar coordinates.Application of the method of separation of variables to separate the Schrödinger equation into the R-. Θ- and Φ- equations and their solutions. Laguerre and Associate d Laguerre polynomials.Wave functions and energies of hydrogen-like atoms, Orbitals. Radial functions and Radial distribution functions and their plots Angular functions (Spherical harmonics) and their plots. Description of Hamiltonians and Schrödinger equation in atomic units (a.u.).

Unit-II Approximation methods **15 hours**

Many electron atoms. Approximate methods in quantum mechanics: The variation theorem, Illustration variation theorem using trial function in particle in box, linear variation principle and perturbation theory for first order correction to energy and wavefunction and second order correction to energy, application of variation method and perturbation theory to the Helium atom, antisymmetry, Pauli exclusion principle, Slatter determinantal wave functions. Electron spin.

Unit III Self Consistent Field Approximations **15 hours**

Hartree-Fock Self Consistent Field method, The Coulomb and Exchange Operators, The Fock Operator, Koopmans' theorem, Brillouin's theorem, The Roothaan Equations, Slater's treatment of complex atoms, Slater orbitals. Pauli principle, Slater determinant and wave function.

Unit IV Chemical Bonding **15 hours**

Born-Oppenheimer approximation, essential principles of the MO method, MO treatment of Hydrogen molecule and the H_2^+ ion. Valence bond treatment of ground state of hydrogen molecule, MO treatment of homonuclear diatomic molecules, Li_2, Be_2, N_2, O_2, O_2^+, O_2^-, F_2 and heteronuclear diatomics, LiH, CO, NO, HF. Correlation diagrams, non-crossing rules, spectroscopic term symbols for diatomic molecules. Theorems in chemical bonding: The Virial theorem, The Hellmann – Feynman theorem.

References

1. Introduction to Quantum Mechanics, L. Pauling and W.B. Wilson, McGraw Hill
2. D. A. McQuarrie, Quantum Chemistry, 3rd ed., Univ. Sci. Books, Mill Valley, California, 1983.
3. I. N. Levine, Quantum Chemistry, 6th ed., Pearson Education, London, 2008.
4. P. W. Atkins, R.S Friedman, Molecular Quantum Mechanics, 5th ed., OUP, Oxford, 2012.
5. J. P. Lowe, Quantum Chemistry 3rd ed., Academic Press, New York, 2008.
6. A. Szabo, N. S. Ostlund, Modern Quantum Chemistry: Introduction to Advanced Electronic Structure Theory, Dover Book ed., Mc.Graw-Hill, New York, 1982.
7. P.W. Atkins, Physical Chemistry, 8th ed., Wiley, New York, 2006.
8. R. K. Prasad, Quantum Chemistry, 3rd ed., New Age International, 2006.
9. D. J. Griffiths, Introduction to Quantum Mechanics, 2nd ed., 2004.
10. J. J. Sakurai, Modern Quantum Mechanics, 2nd ed., 2010.
11. Fundamentals of Quantum Chemsitry, R Anandaraman, McMillan India, 2000

Teaching Learning Strategies

- Provide updated Lecture Sessions
- Promote Interactive Sessions including discussions and demonstrations.
- Provide experiments to engage students actively and visual aids like presentations, videos, and models to enhance understanding.
- Encourage students to ask questions during or after the lectures

Mode of Transaction

- Lectures, seminars, discussions, and demonstrations

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

DISCIPLINE SPECIFIC COURSE (DSC)

STATISTICAL MECHANICS AND NONEQUILIBRIUM THERMODYNAMICS

Course Title	:	**Statistical Mechanics and Nonequilibrium Thermodynamics**
Course Code	:	**KU09DSCCHE418**
Course Type	:	**DSC**
Course Credits	:	**4**
Pre-requisites	:	**Basic knowledge about thermodynamics**

Course Objectives

- To introduce the students to the concepts of statistical and irreversible thermodynamics.
- The statistical treatment of permits to define the concepts of temperature, heatand entropy strictlyfrom first principles without making use of empirical or axiomatic approach
- Emphasis is given so that the examples studied within the course can be easily generalized to any class of materials system the student will encounter in his career thus providing the skills required to accomplish tasks and solve problems by selecting and applying statistical thermodymic methods and tools.

Credits			TeachingHours			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**

4	0	4	4	0	4	50	50	100

Course Outcome:

C 01	Correlate thermodynamic properties and apply them in systems
C 02	Judge the degrees of freedom of systems and understand theories of irreversible thermodynamic systems
C 03	Has thorough knowledge on different classical and quantum mechanical distribution functions
C 04	Can explain the procedures for deriving the relation between thermodynamic parameters such as pressure, temperature, entropy and heat capacity from the distribution functions.

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	1	3	2	0	0	0	2	1	1
CO2	2	2	2	1	3	3	1	0	0	2	1	1
CO3	3	2	2	1	3	3	1	0	0	1	1	1
CO4	2	3	1	1	3	3	0	0	0	2	1	1

Module 1 Statistical Thermodynamics – I 15 hours

1.1 Basic Principles, permutation, probability concept, thermodynamic probality, macrostates and microstates, 1.2 Ensemble averaging, postulates of ensemble averaging. Micro canonical, canonical and grand canonical ensembles, corresponding distribution laws (using Lagrange's method of undetermind multipliers).1.3 Maxwell- Boltzmann statistics, Boltzmann distribution, derivation of the Boltzmann distribution expression, determination of the Boltzmann constant, 1.4 Maxwell distribution law of velocities from Boltzmann distribution expression.

Module 2 Statistical Thermodynamics – II 15 hours

2.1 Partition function and thermodynamic properties Determination and calculation of thermodynamic properties i.e. internal energy, entropy, Helmholtz and Gibbs free energy using partition function,2.2 translational partition function, translational thermodynamic functionSackur-Tetrode equation, 2.3 atoms and monoatomic molecules, , diatomic molecules, vibrational , electronicand nuclearpartition functionseparation of internal partition function,2.4 basic idea of phase -space.

Module 3 Statistical Thermodynamics – III 15 hours

3.1 Rotationaland vibrational energies, entropy due to internal degrees of freedom. 3.2 Rotational partition function, rotational partition function for polyatomic molecules, 3.3 vibrational partition function.3.4 Cluster diagram. Heat Capacity of gases, 3.5 Heat Capacity of Hydrogen, ortho and para hydrogen states, 3.6 The atomic crystals. Einstein theory of atomic crystals,Debye's modification of Einstein's model.3.7 The Bose-Einstein statistics, statistics of a photon gas, 3.8 Fermi-Dirac statistics, Fermi-Dirac systems, electron gas in metals, thermionic emission 3.9 comparison of three statistics.

Module 4 Non-equilibrium Thermodynamics 15 hours

4.1 Meaning and scope of irreversible thermodynamics. 4.2 Thermodynamic criteria for non-equilibrium states, 4.3 Phenomenological laws-linear laws, Onsager's reciprocal relation, 4.4 Non-equilibrium stationary states, Prigogine's principle of entropy production, Coupled phenomena.4.5 Entropy production-specific laws of entropy production in mass transfer, chemical reaction, heat transfer.

References

1. A course on statistical thermodynamic, Kistin and Dorfuran- Academic 19

2. Elements of statistical Thermodynamics, L.K. Nash- Addision Wesley Publishing

3. Elements of statistical Thermodynamics, M.C.Gupta- New age international.

4. Principle of Physical Chemistry, Puri Sharma Pathania

5. McQuarrie, Donald A. (1975). Statistical mechanics. New York: Harper & Row.

6. An Introduction to Chemical Thermodynamics, RP Rastogi, R RMisra, Vikas publication

7. Thermodynamics for Chemist, Samuel Glasttone, East West Publishers

8. Introduction to Thermodynamics of Irreversible Processes, I. Prigogine, Cambridge University Press

9. Non-equilibrium Thermodynamics, SybrenRuurds de Groot, Peter Mazur, Dover Publications

Teaching Learning Strategies

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- Promote Interactive Sessions including discussions and demonstrations.
- Provide experiments to engage students actively and visual aids like presentations, videos, and models to enhance understanding.
- Encourage students to ask questions during or after the lectures

MODE OF TRANSACTION

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1.Distinguish between Fermions and Bosons?

2.Show that at higher temperature, $\frac{NO}{NP}$=3

3. State the Boltzman distribution law. Briefly explain its significant in physical chemistry

4. Define rotational temperature. Explain its significance.

DISCIPLINE SPECIFIC COURSE (DSC)

ADVANCED ORGANIC LABORATORY

Course Title	:	**ADVANCD ORGANIC LABORATORUY**
Course Code	:	**KU09DSCCHE419**
Course Type	:	**DSC**
Course Credits	:	**4**
Pre-requisites	:	**Laboratory skill, organic reactions, mechanism of organic reactions, laboratory safety**

Course Objectives:

- To analyse the given organic compounds using various methods
- To isolate and analyse the certain biologically important natural product components
- To determine quantitatively certain parameters of the components in naturally occurring substances
- To study the practical methodology for the applications of certain organic named reactions

Course Outcomes

CO1	Identify and separate the organic compound and analyse using spectroscopic methods
CO2	Isolate and characterize important components of natural products
CO3	Quantitative determination of various parameters of components of natural products
CO4	Skill and ability to practice important reactions in the laboratory

Mapping of Course Outcome to POs/PSOs

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	3	1	1	3	2	2	2	3	1	3
CO2	3	3	3	2	1	2	2	2	2	2	1	1
CO3	3	2	3	2	3	1	1	1	1	1	2	2
CO4	3	2	3	2	3	3	3	2	3	1	2	3

Module 1 **Advanced mixture analysis** **60 hours**

1Separation and purification of ternary mixture of organic compounds, 1.2Analysis and derivatization of ternary mixture of organic compounds, 1.3Identification and separation of the individual compounds, 1.4.Qualitative analysis of the individual organic compounds, 1.5

Identification of organic compounds by TLC, 1.6.Purification of organic compounds by column chromatography, 1.7.Characterization of organic compounds by spectral methods, 1.8.Preparation of suitable derivative for each of organic components.1.9. TLC and column chromatographic methods of purification of derivatives, 1.10. Spectral characterization of derivatives.1.11. Fractional crystallization, 1.12. Fractional distillation

Module 2 **Isolation of natural products** **60 hours**

2.1. Isolation and characterization of natural products: Caffeine and Recinoleic acid, 2.2. Isolation and characterization of natural products: Azelic acid, Piperine, 2.3. Isolation and characterization of natural products: Hespiridine and Cysteine, 2.4. Isolation and characterization of natural products: Casein and Lycopene, 2.5. Isolation of Carotenes, 2.6. Purification of natural product extract by paper, TLC and column chromatography, 2.7.Preparation of soaps and detergents, 2.8, Extraction of Groundnut oil and Coconut oil, 2.9Determination of various components of natural products by polarity based solvent extraction, 2.10. Identification of individual compounds present in each fraction of natural product extraction

Module 3 **Quantitative analysis** **60 hours**

3.1. Quantitative determination of sugars and amino acids by various methods, 3.2. Quantitative determination of carboxylic acids, amides and esters by various methods, 3.3.Determination of functional groups like hydroxyl, vic-hydroxyl and enol by various methods, 3.4.Determination of functional groups like amino, amide, unsaturation and nitro groups by various methods, 3.5.Determinations of acid and amide in a mixtures, 3.6. Determinations of acid and ester in a mixtures, 3.7. Determination of Saponification and Iodine values of oils and fats.

Module 4 **Organic synthesis** **60 hours**

Laboratory scale preparations of organic named reactions. Monitoring of the reaction by TLC. Purification by column chromatography. Determination of melting point and Spectroscopic identification using UV, IR and NMR; 4.1.Acyloin condensation, 4.2.Aldol condensation, 4.3.Beckmann rearrangement.4.4. Cannizzaro reaction, 4.5. Claisen condensation, 4.6.Fries rearrangement, 4.7.Perkin reaction, 4.8.Sandmeyer reaction

References:

1. Advanced Practical Organic Chemistry, III Edition, J. Leonard, B. Lygo and G. Procter, CRC Press, Routledge, (2013).
2. Advanced practical organic chemistry, J. Mohan, Vol. I and II, Himalaya Publishing House, (1992).
3. An advanced course in practical chemistry, A. Ghoshal, B. Mahapatra and A.Kr. Nad, New central book agency, Calcutta, (2000).
4. Comprehensive practical organic chemistry: Qualitative analysis, V. K. Ahluwalia, S. Dhingra, Universities Press (India), (20000.
5. Elementary Practical Organic Chemistry-Vol. III quantitative Organic Analysis- A.I Vogel Pearson India; 2nd edition (2010)
6. Experimental Organic Chemistry- H.D. Durst & G.E. Goke (McGraw-Hill) (1980)
7. Experimental Organic Chemistry- Vol. I &II- P.R. Singh, Tata McGraw-Hill, (1981).
8. Laboratory Experiments in Organic Chemistry-Adam, Johnson &Wicon (McMillan, London), (1979).
9. Practical organic chemistry (Quantitative analysis), B.B. Dey, M. V. Sitaraman and T. R. Govindachari, Allied Publishers, New Delhi, (1992).
10. Comprehensive Practical Organic Chemistry, V K. Ahluwalia, RenuAggarwal, Universities Press (2000)
11. Practical organic chemistry- a student handbook of techniques, J T. Sharp, I Gosney and A G Rowley, Chapman and Hall, Springer (2012)

Teaching Learning Strategies

- Improving skill development of laboratory preparations

- Experiencing the background of laboratory reactions
- Systemizing the laboratory works
- Making the awareness of chemistry of natural products

Mode of Transactions

• Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. How TLC is useful in identifying organic compounds?
2. How will you analyse carotenes?
3. How will you determine the percentage of acid in a mixture of acid and amide
4. Discuss the steps involved in the practical synthesis of Perkin reaction

DISCIPLINE SPECIFIC COURSE (DSC)

BIOINORGANIC CHEMISTRY

Course Title	:	**Bioinorganic Chemistry**
Course Code	:	**KU09DSCCHE420**
Course Type	:	**DSC**
Course credit	:	**4**
Prerequisites	:	**Basic Inorganic chemistry & Coordination Chemistry**

Course Objectives

- The learners should be able to apply theories of chemical bonding, reaction mechanism, electronic structure and magnetic properties of coordination complexes to identify the occurrence, active site structure and functions of some transition metal ion containing metalloproteins or enzymes.

Credits	Teaching Hours	Assessment

L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
4	0	4	4	0	4	50	50	100

Course Outcomes:

CO1	Identify elements in biology, their occurrence and function.
CO2	Interpret structure and function of metalloproteins with various transition metal ions and ligand system.
CO3	Understand transport mechanism by metalloproteins.
CO4	Identify application of metal ions in biology for medicinal purpose.
CO5	Utilize the principles of transition metal coordination complexes in understanding functions of biological systems.

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3	3	2	2	3
CO2	3	3	3	3	3	3	3	2	2	3	3	3
CO3	3	3	3	3	3	3	3	3	2	2	3	3
CO4	3	3	3	3	3	3	3	3	2	3	3	3
CO5	3	3	3	3	3	3	3	3	2	3	3	3

Module 1: Elements in Biology **15 hours**

Introduction to Bioinorganic Chemistry, Distribution of elements in biological systems.Bulk, Essential, Trace and Ultra trace elements, Role of metal ions in biological functions.

Biological role of some trace non-metals (B, Si, S, Se, As, Cl, Br, I), Elements of life: Water, sugars, polysaccharides, amino acids, peptides, proteins, nucleosides, nucleotides, nucleic acids, lipids and phosphates. Protein synthesis and DNA replication.

Module2: Oxygen transport **15 hours**

Iron in biological systems, Haemoglobin (Hb) and myoglobin (Mb), transport of oxygen by heme proteins, co-operativity of oxygen binding, reversible oxygen binding, binding of CO to Hb and Mb, Bohr effect, Hemerythrin, Storage and transport of metal ions: ferritin, transferrin, siderophores.

Copper in biological systems: ceruloplasmin, copper in oxidase activity, structure and functions of haemocyanin, azurin, plastocyanin, Type I, II and III copper protein models.

Module 3: Miscellaneous Metallozymes **15 hours**

Metalloenzymes and metal activated enzymes, Zn(II) and Mg(II) containing enzymes, Iron enzymes, cytochromes and their roles in biological systems. and the mechanism of its activity. Enzymes containing Zn, Cu, Fe, Mn, Ni, Mo, W. (Carboxy peptidase, Carbonic anhydrase, alcohol dehydrogenase, Catalase, Peroxidase, Cytochrome P450, Urease, Nitrogenase etc. Transport of ions across membranes: ionophores, active and passive transport, Na+/K+ pump in biological system. Structural role of calcium, transport of calcium, intra and extra cellular calcium binding, role of calcium in blood clotting.

Module 4: Metals in medicine, photosynthesis and nitrogen fixation **15 hours**

Diseases caused by excess and deficiency of metal ions, metals in medicine, metal ion based drugs (Pt, V and Au), metal ions as diagnostic agents, MRI imaging and contrast agents, toxicity due to non-essential elements and speciation.Chelation theory and chemotherapy, metal detoxification mechanism.

Photosynthesis: Chlorophyl: PS I and PS II

Biological nitrogen fixation: nitrogenase, Fe-S clusters, Fe-protein structure, P-cluster and M-centre, nitrogenase model system.

References

1 Inorganic Biochemistry, G.L. Eichhom(Ed), Vol. 1 and 2, Elsevier, 1973.

2 Biocoordination Chemistry, D. E. Fenton, (Chemistry Primer 26), Oxford Univ. Press, 1995.

3 Bioinorganic Chemistry, L. Bertini, H. B. Gray, S. J. Lippard, and J. S. Valentine, Univ. Science Books, 1994.

4 Bioinorganic Chemistry, R.W. Hay, Ellis Harwood, 1984.

5 Metal ions of Biological Systems, H. Siegel and T. G. Spiro, Marcel-Dekker, 1980.

6 Principles of Biochemistry, A. L. Lehninger, D. L. Nelson and M. M. Cox, CBS Publishers and Distributors, 1993.

7 Principles of Bioinorganic Chemistry, S. J. Lippard & J. M. Berg, Univ. Science Books.

11. Metal in Biochemistry, P.M. Harrison and R.J. Hoare, Chapman and Hall,1980.

12. The Inorganic Chemistry of Biological Processes, M.N. Hughes, Wiley, 1981.

13 Bioinorganic chemistry, Asim K. Das, Books & Allied (P) Ltd. 2013

14 Bioinorganic and Supramolecular chemistry, P.S Kalsi and J.P Kalsi, Newage International Publishers, 2008.

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting Active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminars	10	
	Viva	10	

Sample Questions to test Outcomes

1. Give an account of trace and ultra trace elements in human body.
2. Illustrate oxygen transport by hemoglobin.
3. Explain Na+/K+ pump for ion transport in cell.
4. Comment on biological nitrogen fixation.

FOUNDATION COURSES

DEPARTMENT OF CHEMISTRY

(Effective from 2024 admissions)

KANNUR UNIVERSITY

MDC COURSES

UNDERSTANDING THE NANOWORLD

Course Title	**:**	**UNDERSTANDING THE NANOWORLD**
Course Code	**:**	**KU01MDCCHE101**
Course Type	**:**	**MDC**
Course Credits	**:**	**3**
Pre-requisites	**:**	**Basic awareness of concepts in physics and chemistry**

Course Objectives:

- To acquire awareness on the importance of Nano-technology, Emergence of Nanoscience and technology and challenges in Nanotechnology.
- To gain understanding of physical chemical and mechanical properties of low dimensional systems.
- To understand the basic science required to know the fundamentals of nanostructures and their types.

Credits			Teaching Hours			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	0	3	3	0	3	50	50	100

Course Outcome:

C 01	Explain the fundamentals and opportunities of Nanoscience and Nanotechnology.
C 02	Classify different types of nanostructures based on quantum confinement.
C 03	Interpret specific properties of nanomaterials in the nano-regime.

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3	3	2	2	3
CO2	3	3	3	3	3	3	3	2	2	3	3	3
CO3	3	3	3	3	3	3	3	3	2	2	3	3

Module 1 **15 hrs**

1.1. History of Nanotechnology, 1.2 Feynmann's vision on nanoscience & technology, 1.3 bulk vs nanomaterials. 1.4 Central importance of nanoscale morphology - small things making big differences, 1.5 nanotechnology as nature's technology, 1.6 clusters and magic numbers, 1.7 nanoscale architecture. 1.8 Recent developments, challenges and future prospects of nanomaterials.

Module 2 **15 hrs**

2.1 Size and shape dependent chemical properties- Melting points and lattice constants, Surface Tension, Wettability 2.2 density of states, 2.3 Specific Surface Area and Pore 2.4 Composite Structure, 2.5 Mechanical properties, 2.6 Optical properties: Surface plasmon resonance in metal nanoparticles and quantum size effect in in Semiconductors, 2.7 Electrical conductivity: Surface scattering, change of electronic structure, quantum transport, effect of microstructure, 2.8 Magnetic properties: superparamagnetism,

Module 3 **15 hrs**

3.1 Classification based on the dimensionality, 3.2 Zero-dimensional nanostructures: metal, semiconductor and oxide nanoparticles. 3.3 One-dimensional nanostructures: nanowires and nanorods, 3.4 Two-dimensional nanostructures: Thin films, 3.5 Three-dimensional nanomaterials, 3.6 Special Nanomaterials: Carbon fullerenes and carbon nanotubes, micro and mesoporous materials, core-shell structures, organic-inorganic hybrids.

References

1. G. Cao and Y.Wang, Nanostructures and Nanomaterials, 2nd Ed., Imperial College Press, 2004. 26
2. R. Kelsall , I.Hamley and M. Geoghegan, Nanoscale Science and Technology, Wiley, 2005.
3. K. J Klabunde, R. M. Richards, Nanoscale Materials in Chemistry, 2nd Ed., Wiley, 2009.
4. T. Pradeep, A text book of Nano Science and Technology, Tata McGraw-Hill Education, 2012. 5. G. Schmidt, Nanoparticles: from Theory to applications, Wiley-VCH, 2004

Teaching Learning Strategies

- Provide updated Lecture Sessions
- Promote Interactive Sessions including discussions and demonstrations.
- Provide experiments to engage students actively and visual aids like presentations, videos, and models to enhance understanding.

- Encourage students to ask questions during or after the lectures

MODE OF TRANSACTION

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Show mathematically that the surface to volume ratio of nanoparticles is much higherthan that of the bulk particle of the identical material?
2. Briefly explain the progress of Nanotechnology over years?
3. Give an account on the challenges associated with Nanotechnology as an emerging field?
4. How does the arrangement of nanostructures affect the wettability in leaves?

MULTY DISCIPLINARY COURSES (MDC)
BASIC BIOCHEMISTRY AND INTRODUCTION TO BIOMOLECULES

Course Title	:	**BASIC BIOCHEMISTRY AND INTRODUCTION TO BIOMOLECULES**
Course Code	:	**KU02MDCCHE102**
Course Type	:	**MDC**
Course Credits	:	**3**
Pre-requisites	:	**Basic awareness of concepts in Biochemistry**

Course Objectives:

- To acquire awareness historic perspective of Biochemistry
- To gain understanding of Structure of amino acids, protein and DNA
- To understand the Biological significance of biomolecules

Credits			Teaching Hours			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	0	3	3	0	3	50	50	100

Course Outcome:

C 01	Explain the fundamentals Biochemistry
C 02	Classify different types protein and DNA
C 03	interpret applications of biomolecules

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3	3	2	2	3
CO2	3	3	3	3	3	3	3	2	2	3	3	3
CO3	3	3	3	3	3	3	3	3	2	2	3	3

Unit 1: **15 hours**

Introduction to Biochemistry: The foundations and historic prospective of biochemistry Cellular and chemical foundations of life. Carbohydrates: Classification, preparation, properties and structure. Properties, structure and biological functions of mono, di, oligo and polysaccharides. Homopolysaccharides and Heteropolysaccharides.

Unit 2: **15 hours.**

Amino acids: Structure, classification and chemical reactions. peptide bond. Proteins.Biological importance, Forces stabilizing the structure of proteins.classification, general properties, primary structure, Secondary, tertiary and quaternary structures. Denaturation.Nucleic acids - Purine and Pyrimidines – structure and properties.Nucleosides.Nucleotides.DNA and RNA.Composition, structure, their biological importance, Comparison between DNA and RNA.

Unit 3: **15 hours**

Lipids: Biological significance, classification. Structure, properties and functions- Fatty acids, triglycerides, waxes, terpenes, cholesterol and its derivatives. Compound lipids- Phosphoglycerides, sphingolipids and glycolipids

Text Books:

1. Biochemistry by N.Arumugam, Saras Publications, 3rd edition (2010)
2. Biochemistry by U.Sathyanarayana, Allied Books Publishers, 4th edition, 2007

Reference Books:

1. Biochemistry by Lubert Stryer, Free man Publishers Ltd, 5th edition (2002).
2. Biochemistry by Voet & Voet, Wiley Publications, 2nd Edition (2003)

MULTY DISCIPLINARY COURSES (MDC)

Course Title : **BIOPOLYMERS**
Course Code : **KU03MDCCHE201**
Course Type : **MDC**
Course Credits : **3**
Pre-requisites : **Basic awareness of concepts in polymers**
Course Objectives

- To identify various biopolymers and their applications
- To Compare the properties and applications of biopolymers
- To explain different types of polymerization reactions
- To introduce various classes of biopolymers and bioplastics

Course Learning Outcomes

- List out different classes of biopolymers and their applications
- Classify biopolymers according to their type, origin and monomers.
- Explain vast applications of biopolymers in different areas such as biomedical field and agriculture.
- Explain the mechanism of different polymerization reactions

Credits			TeachingHours			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	0	3	3	0	3	50	50	100

Course Outcome:

C 01	Explain the fundamentals Biopolymers
C 02	Classify different types protein and DNA
C 03	interpret applications of biopolymes

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3	3	2	2	3
CO2	3	3	3	3	3	3	3	2	2	3	3	3
CO3	3	3	3	3	3	3	3	3	2	2	3	3

Unit 1 **15 hrs**

Importance of monomers and polymers, Types of polymerisation reactions, addition polymerisation, condensation polymerisation, copolymerisation, Definition of biopolymers and types of biopolymers, Classification on the basis of type: Sugar-based polymers, Starch-based polymers, Cellulose-based biopolymers, Classification on the basis of origin: Natural biopolymers, Synthetic biopolymers, Microbial polymers. Classification on the basis of monomeric units: Polysaccharides, Proteins, Definition of bioplastics and types of bioplastics.

Unit 2 **15 hrs**

Bioplymers from Natural Origin: Structure, property and applications of Polysaccharides (starch, cellulose, lignin, chitin), Proteins (gelatine, casein, wheat gluten, silk and wool), Lipids (plant oils including castor oil and animal fats). polyesters produced by micro-organism or by plants (polyhydroxy alkanoates, poly-3-hydroxybutyrate), polyesters synthesized from bioderived monomers (polylactic acid), miscellaneous polymers (natural rubbers).

Unit 3 **15 hrs**

Biopolymers from mineral origin: Aliphatic polyesters (polyglycolic acid, polybutylene succinate, polycaprolactone), aromatic polyestyers (polybutylene succinate terephthalate), polyvinyl alcohols, modified polyolefins and their applications, Biodegradability

Text books:

1. Biopolymers and Biomaterials, Edited By Aneesa Padinjakkara, Aparna Thankappan, Fernando Gomes Souza, Jr., Sabu Thomas, CRC Press 2019.
2. Handbook of Biopolymers and Biodegradable Plastics: Properties, Processing and Applications, Sina Ebne sajjad, Elsevier, 2013.
3. Biodegradable Polymers for Industrial Applications, Ray Smith, CRC Press, 2005.
4. Handbook of Biodegradable Polymers: Isolation, Synthesis, Characterization and Applications, Editor(s): Prof. Andreas Lendlein, Dr. Adam Sisson, 2011.
5. Geoffrey Allen, John C. Bevington, Comprehensive Polymer Science and Supplements, Pergamon, 1989.
6. Biopolymers: Processing and Products, William Andrew Publishing, 2015

VALUE ADDED COURSES (VAC)

WATER QUALITY ANALYSIS

Course Title	:	**Water Quality Analysis**
Course Code	:	**KU03VACCHE202**
Course Type	:	**VAC**
Course Credits	:	**3**
Pre-requisites	:	**Basic analytical techniques**

Course Objectives

- To build fundamental knowledge and skills in water quality analysis
- To understand the physical, chemical, and biological characteristics of water.
- To train the students with laboratory skills required for water quality monitoring.
- To develop awareness about the various water quality parameters and standards.

Credit			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
2	1	3	2	1	3	50	50	100

Course Learning Outcomes

C01	Conceptually explain and carry out various water quality analysis.
C02	Critically analyze water quality data
C03	Analyze the physical, chemical and biological characteristics of water.
C04	Perform the different methods for the determination of water quality parameters

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	2	3	3	2	2	2	3	1	3
CO2	3	3	3	2	3	3	2	2	2	3	1	3
CO3	3	3	3	2	3	3	2	2	2	3	1	3
CO4	3	3	3	2	3	3	2	2	2	3	1	3
CO5	3	3	3	2	3	3	2	2	2	3	1	3

Module I: 15 Hrs.

Water Quality Fundamentals: Chemistry of water, Physical and chemical properties, Water resources, water pollution, impurities in water. Important water Quality parameters -Turbidity, colour, taste, pH, acidity, alkalinity, Salinity, chemical constituents-chlorides, nitrates, suphates, fluoride. Hardness, types of hardness, causes of hardness, total hardness, unit of hardness, Degree of hardness, removal of temporary hardness, dissolved oxygen, BOD, COD. Winkler's method.

Module II: 15Hrs.

Practical-I Laboratory tests for water quality monitoring: Determination of pH, turbidity and conductivity, Test for acidity and alkalinity, Tests for chloride by Argentometric method, Nitrate by colorimetric method, Sulphate by gravimetric method, fluoride by colorimetric method.

Module III: 15Hrs.

Practical-II: Determination of hardnessby EDTA method. TDS (Total dissolved solids) determination. Winkler's method for Dissolve oxygen (DO) analysis, Determination of BOD by Winkler's method, Determination of COD.

References

1. Droste, Ronald L. (1997). Theory and Practice of Water and Wastewater Treatment. New York, New York: John Wiley & Sons, Inc.
2. Methodology of water analysis; M.S. Kodarkar, IAAB Publication, Hyderabad
3. Engineering Chemistry, Wiley second edition (2013).
4. Principles and Practice of Analytical Chemistry- Fifield and Kealey, Blackwell publishers (2000).
5. Cowan, P. A.; Porcella, D. B.; Adams, V. D.; and Gardner, L. A., "Water Quality Analysis Laboratory Procedures Syllabus" (1978).

Teaching Learning Strategies

- Provide lectures and experiments to engage students actively and use visual aids like presentations, videos, and models to enhance understanding.
- Encourage students to ask questions during or after the lectures and practical sessions.
- Allow students to conduct experiments under supervision.
- Provide students with the required safety instructions and guidelines for lab work

MODE OF TRANSACTION

• Discussions and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External lab Exam	50	50
Continuous Evaluation	Internal lab Exam	40	50
	Viva	10	

Sample Questions to test Outcomes.

5) How to determine the hardness of water by EDTA method?
6) Determine the amount of dissolved oxygen in the given water sampleby winkler's method
7) Distinguish between temporary hardness and permanent hardness.
8) What is BOD and COD?

VALUE ADDED COURSES (VAC)

FOOD ADULTERATION

Course Title	**:**	**FOOD ADULTERATION**
Course Code	**:**	**KU04VACCHE203**
Course Type	**:**	**VAC**
Course Credits	**:**	**3**
Pre-requisites	**:**	**Basic Knowledge food chemistry**

Course Objectives:

- This course aims to teach students about foods as chemical systems.
- Outlining the nutrients, or necessary food components, that comprise these systems
- The processes that underlie the changes that take place to food as it is processed and stored.
- Students will be conversant with food nanotechnology and analytical methods.

Credit			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

Course outcomes:

After the completion of the course, the learners should be able to

C01	Understanding fundamentals of food chemistry
C02	To acquire knowledge in Food Additives, Preservatives, and Contaminants
C03	To gain concepts on food composition and nutritional aspects
C04	Familiarity with analytical methods and Nanotechnology in food science

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	1	1	2	3	2	2	2	1	3	2	2
CO2	2	1	2	2	3	2	2	2	1	3	2	2
CO3	2	1	2	2	3	2	2	2	1	3	2	2
CO4	3	1	2	2	3	2	2	2	1	3	2	2

Module 1: Introduction to Food Chemistry **15 hours**

Purpose of food, classification of food, Chemical composition of food: Carbohydrates, lipids, proteins, fiber, vitamins, and minerals, Need and methods of food adulteration, prevention of adulteration. Common foods subjected to adulteration, poisonous and non-poisonous Safe levels of additive uses. Preservation of processed foods.Effects of adulterations, Food hygiene, General impact on Human health, Food borne diseases and food poisoning

Module II: Chemistry of Adulteration **15 hours**

Adulteration – definition, types, Role of additives in processed foods. Examples of materials used for adulteration. Common methods of detection adulterants in food materials, Oil, grain, sugar, salt, spices and dairy, beverages, Processed food, sweetening agents. Highlights of Food Safety and Standards Act. Rules and procedures of local authorities, Consumer education and Quality control laboratories, Procedures to Complain and Penalties, Food regulation in the Indian and Global context.

Module III. Laboratory methods for Determination of Adulteration **15 hours**

Determination of adulteration in edible oils.Iodine value, saponification value, UV spectroscopy.Refractive index.Adulteration in milk. Determination of density, fat content, total dry-extract, tests for presence of chemicals such as formaldehyde, sugar, etc. Turbidimetry, pH meter, Adulteration in powdered spices. Red lead salts/brick powder in chilli powder, yellow lead salts/ colored saw dust in turmeric powder.

References

1. A Laboratory Manual of Food Analysis, S. Sehgal, Wiley Publishers.
2. Food Safety and Standards Act, 2006. Bare ACT, November 2020, Commercial law publishers.

3. Food Safety, case studies–Ramesh.V.Bhat,NIN,1992
4. The Food Safety & Standards Act 2006, Virag Gupta, Commercial Law Publishers India Pvt Ltd.
5. Food Microbiology, Frazier and Westhoff, Tata McGraw Hill Publishers, New Delhi
6. Clinical Dietetics and Nutrition, Antia F P, 4th edition, 1997, Oxford university press, New Delhi.

Teaching Learning Strategies

- Provide updated Lecture Sessions
- Promote Interactive Sessions including discussions and demonstrations.
- Provide experiments to engage students actively and visual aids like presentations, videos, and models to enhance understanding.
- Encourage students to ask questions during or after the lectures

MODE OF TRANSACTION

• Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminar	10	
	Viva	10	

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SKILL ENHANCEMENT COURSES (SEC)

CHROMATOGRAPHIC TECHNIQUES

Course Title	:	**CHROMATOGRAPHIC TECHNIQUES**
Code	:	**KU04SECCHE204**
Course Type	:	**SEC**
Course Credits	:	**3**
Pre-requisites	:	**Basic Analytical Concept, Organic Compounds**

Course Objectives:

- To inculcate the basic understanding of Chromatographic Techniquesand its interdisciplinary applications among the students.
- To provide training in the principles and practice of chromatographic techniques.
- To provide an understanding of chemical methods employed for compound separation analysis.
- To provide the over view of the applications of these concepts in various field to students.

Credit			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	72	0	72	40	60	100

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	Remember the basic concepts of Chromatography like paper, TLC, Column, GC & HPLC
C02	Understand the significance of paper, TLC, Column, GC & HPLC in separation and identification of compounds
C03	Apply the conceptual knowledge gained in the techniques of chromatography in separating and identifying the chemical compounds as and when required
C04	Analyse that how far one chromatographic technique is much use full in separation and identification of compounds over the other chromatographic technique

Credit			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	4	0	4	50	50	100

Mapping of Course Outcomes to POs/PSOs:

	PSO 1	PSO 2	PSO 3	PSO 4	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
C0 1					2	3	1	1	1	1	1	2
C0 2					2	3	1	1	1	1	1	2
C0 3					2	3	1	1	1	1	1	2
C0 4					2	3	1	1	1	1	1	2

Module 1. Introduction to Chromatographic Techniques 15 hours

1.1.Solvent Extraction: Introduction, principle, techniques, 1.2.factors affecting solvent extraction, 1.3.Batch extraction, continuous extraction and counter current extraction.

1.4.Principle of chromatographic technique, 1.5.terms and parameters used in chromatography, 1.6.classification of chromatographic methods, 1.7.partition versus adsorption chromatography, 1.8.qualitative and quantitative analysis by chromatography

Module 2. Planar Chromatography 15 hours

2.1.Paper Chromatography: Principle, 2.2.experimental modifications, nature of the paper, detection of spots, 2.3.retardation factors, factors that affect the reproducibility of Rf values (due to paper, solvent system, sample, development procedure), 2.4.selection of solvent, 2.5.quantitative analysis. 2.6.applications

2.7.Thin layer chromatography: Principle, High performance Thin Layer Chromatography (HPTLC), stationary phase, adsorbents, liquid phase supports, plate preparation, mobile phase, sample application, development, saturation of chamber, detection of spot, Rf values (effect of adsorbent, solvent, solute, development process), quantitative analysis, 2.8.applications.

Module 3. Column and Gas Chromatography 15 hours

3.1.Adsorption Chromatography: Principle, adsorbents, solvents, nature of solute, operating parameters, retention volumes and times, applications. 3.2.Column Chromatography: Principle, columns, matrix materials, stationary phase, column packing, application of sample, column development and sample elution, detectors and fraction collectors.

3.3.High Performance Liquid Chromatography: Principle, column, matrices and stationary phases, column packing, mobile phase and pumps, detectors, Types of HPLC–Normal phase HPLC, Reverse Phase HPLC.

3.4.Gas Chromatography (GC): Instrumentation, selection of operating condition, carrier gases, stationary phases, choices of GC column, temperature selection, sampling techniques, Detectors.

References:

1. R.P.W Scott, Techniques and practice of Chromatography, Marel Dekker Inc., New York .
2. M.N. Sastri ,Separation methods, Himalaya Publishing Company, Mumbai.
3. E. Helfman, Chromatography, Van Nostrand, Reinhold, New York .
4. E. Lederer and M. Lederer, Chromatography, Elsevier, Amsterdam.
5. Chemical separation methods, John A Dean, Von Nostrand Reinhold, New York
6. R.P.W Scott, Techniques and practice of Chromatography, Marel Dekker Inc., New York
7. H.M Mc Nair and J. M. Miller, Basic Gas Chromatography, John Wiley, New York
8. W. Jeumings, Analytical Gas chromatography, Academic Press, New York
9. H. Eugelhardt (ed), Practice of HPLC, Springer Verrag, Berrin.
10. O. Mikes, R.A. Chalmers: Laboratory Handbook of Chromatographic Methods.

Teaching Learning Strategies

- Provide updated Lecture Sessions
- Promote Interactive Sessions including discussions and demonstrations.
- Provide experiments to engage students actively and visual aids like presentations,
- Videos and models to enhance understanding.
- Encourage students to ask questions during or after the lectures

Mode of Transaction

- Lectures, seminars, discussions, and demonstrations.

ASSESSMENT RUBRICS			Total
End Semester Evaluation	External Exam	50	50
Continuous Evaluation	Internal Exam	20	50

	Assignment	10	
	Seminar	10	
	Viva	10	

Sample Questions to test Outcomes

1. Define Rf value, Explain factors effecting the Rf values.
2. Explain the applications of paper chromatography
3. Write briefly about experimental procedure for column chromatography.
4. Explain the classification of column chromatography
5. Explain Ascending and descending techniques in paper chromatography

SKILL ENHANCEMENT COURSE (SEC)

SAFETY LABORATORY PRACTICES

Course Title : **SAFETY LABORATORY PRACTICES**
Course Code : **KU05SECCHE301**
Course Type : **SEC**
Course credit : **3**
Prerequisites : **Basic science**
Course Objectives

- To introduce the students about the safe practices, basic laboratory procedures and protocols for a job laboratory situation.
- To orient students about safe handling of chemicals and glass wares and to take precaution against accidents by following safety measures.
- To learn Standard Operating Procedures (SOPs) of Laboratory equipments

Credits			Teaching Hours			Assessment		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
3	0	3	3	0	3	50	50	100

Course Outcomes:

CO1	Develop skill in safe-handling of chemicals and laboratory equipment.
CO2	Understand the safely practices, basic laboratory procedures and protocols for a job laboratory situation.
CO3	Understand the precautions to be taken to avoid lab accidents by following the safety measures.

CO4	Understand the basic calibration and handling of basic laboratory instruments.

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3	3	2	3	3
CO2	3	3	3	3	3	3	3	3	3	3	2	3
CO3	3	3	3	3	3	3	3	3	3	3	2	3
CO4	3	3	3	3	3	3	3	3	3	2	3	3

Module 1: 15 hours

General rule and protocols for lab safety measures, precaution and safety in handling of chemicals, laboratory tools, glass wares and instruments. Awareness of Material Safety Data Sheet (MSDS). Storage and handling of chemicals. Maintenance and cleaning of laboratories.

Personal Protective and other safety equipment and their uses: Lab safety signs, various safety goggles, types of gloves, apron, masks, different filters for masks, face shield, full body suit, safety shoes. Eye wash fountains and safety showers.

Module 2: 15 hours

Simple first aids: Electric shocks, fire, cut by glass and inhalation of poisonous gases – Accidents due to acids and alkalis – Burns due to phenol and bromine. Disposal of sodium and broken mercury thermometer.

Fire extinguishers and their periodic inspection. First aid kit, its contents and need for monitoring. Emergency exit, its location and approach path. Spills, injuries, fires, building evacuations, emergencies. Fire drill and chemical accident drills. Accident recording and investigation for future controls.

Module 3: 15 hours

Safe storage and use of hazardous chemicals. Waste Management: waste classification, hazardous waste, non-hazardous waste, mixed waste. Safe storage and disposal of chemical waste.

Preparation of standard solution and buffers.

Calibration of instruments: pH meter, balances, colorimeter, spectrophotometer, water bath, distillation assembly, burette, pipette etc.

Reference:

1. Guidelines for good laboratory practices-Indian council of medical research, New Delhi (2008)
2. Chemical Laboratory Safety and Security: A Guide to Prudent Chemical Management, Lisa Moran and Tina Masciangioli, Editors, The National Academies Press Washington,
3. Safety in Academic Chemical Laboratory, Vol. II, ACS Publication, 7th Edition (2003).
4. A Primer for Good Laboratory Practices and Good Manufacturing Practices, L. Huber, Agilent Technologies, 2002.
5. Handbook of Good Laboratory Practices, TDR, WHO, UNICEF, UNDP (2009).

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting Active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			**Total**
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminars	10	
	Viva	10	

Sample Questions to test Outcomes

1. What do you understand by Material Safety Data sheet?.
2. Write on first aid to be given for victim after an accident due to acid.
3. Define buffer.

SKILL ENHANCEMENT COURSE (SEC)

ADVANCED TECHNIQUES FOR CHARACTERIZATION OF MATERIALS

Course Title	**:**	**ADVANCED TECHNIQUES FOR CHARACTERIZATION OF MATERIALS**
Course Code	**:**	**KU06SECCHE302**
Course Type	**:**	**SEC**
Course credit	**:**	**3**
Prerequisites	**:**	**Basic of spectroscopy and thermal techniques**

Course objectives

- The aim of the course is to provide the students with an overview of sophisticated instrumentation techniques emphasized with special reference to the principles, practice and applications of UV-Visible spectroscopy, X-ray diffraction, thermal and electrochemical techniques.

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	Explain the principles and operation of a range of advanced techniques such as UV-Visible spectroscopy, X-ray diffraction, thermal and electrochemical instruments used in characterization of various materials.
C02	Develop an idea about the crystal structure of materials and their by its structure - property relations.
C03	Understanding, from a microstructural point of view, the thermal properties of materials and related applications.
C04	Hand on experience of instruments and interpretation of results. Apply the skills gained in research and industrial explores

Mapping of Course Outcomes to POs/PSOs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3	3	2	3	3
CO2	3	3	3	3	3	3	3	3	3	3	2	3
CO3	3	3	3	3	3	3	3	3	3	3	2	3
CO4	3	3	3	3	3	3	3	3	3	2	3	3

Module 1 Spectroscopic techniques **15 hours**

Theory of Ultraviolet and Visible Spectroscopy: Internal conversion, conical intersection, Principle, solvent effects, Instrumentation and applications of UV-Visible, spectroscopy, FT-IR Raman and Fluorescence spectroscopy, Practical: Hands on experience of operation with UV-Vis-, Raman and data analysis

Module 2 Xray Techniques **15 hours**

Theory: Principle, Theory- X-ray spectral lines, instrumentation, Powder XRD and Single crystal XRD X-ray Diffraction, Analysis with X-ray diffraction, applications. Practical: Instrumentation, sampling and hands on experience with instruments for analysis.

Module 3 Thermal techniques **15 hours**

Thermo gravimetric methods of analysis (TGA): Instrumentation, applications TGA for quantitative analysis and problems based TGA. Differential Scanning Calorimetry (DSC): Principle, Instrumentation, Applications Practical: Instrumentation, sampling, Hands on experience of operation with DSC and TGA and interpretation of Data.

Teaching Learning Strategies

- Developing conceptual understanding
- Using visual aids and real-world applications
- Emphasizing problem solving skills
- Promoting Active learning

Mode of Transactions

- Lectures, seminars, discussions, and demonstrations.

Assessment Rubrics			Total
End Semester Evaluation	External Test	50	50
Continuous Evaluation	Internal Exams	20	50
	Assignments	10	
	Seminars	10	
	Viva	10	

Sample Questions to test Outcomes

1. Discuss the principle of X Ray crystallography.
2. Write down the Debye Scherrer formula for calculating grain size.
3. Briefly explain the principle of X Ray Fluorescence.
4. What are the advantages of ATR over other IR sampling techniques?
5. Distinguish between TG, DTG and DTA?