BOARD OF STUDIES MEMBERS

List of Board of Studies Members for the Department of Applied Physical & Material Sciences, University of Swat

S.No	Name	Convener/Member
1	In-charge, Department of Applied Physical and Material Sciences, UoS	**Convener**
2	Dr. Muneeb Ur Rahman, Associate Professor Islamia College University, Peshawar	**Member**
3	Mr. Afzal Khan, Associate Professor GPG Jehanzeb College, Saidu Sharif Swat	**Member**
4	Dr. Faiz Muhammad Khan, Assistant Professor Department of Mathematics & Statistics, UoS	**Member**
5	Dr. Muhammad Umar, Assistant Professor Institute of Chemical Sciences, UoS	**Member**
6	Mr. Israr Ahmad, Assistant Professor GPG Jehanzeb College, Saidu Sharif Swat	**Member**
7	Mr. Muhammad Karam, Assistant Professor GPG Jehanzeb College, Saidu Sharif Swat	**Member**
8	Dr. Kefayat Ullah, Assistant Professor Department of Applied Physical & Material Sciences, UoS	**Member**
9	Mr. Murad Ali, Lecturer GPG Jehanzeb College, Saidu Sharif Swat	**Member**
10	Mr. Muhammad Babar Azam Khan, Lecturer Department of Applied Physical and Material Sciences, UoS	**Member**

MINUTES OF THE 1st BOARD OF STUDIES MEETING

The 1st meeting of the "Board of Studies" of the Department of Applied Physical & Material Sciences was held on the 15th May 2018, at 11:00 am, at the Committee Room, Sector-F, Kanju Township, University of Swat. The meeting was chaired by the In-Charge, Department of Applied Physical & Material Sciences, Assistant Professor: Dr. Amin Ur Rashid. The meeting was formally started with the recitation of the Holy Quran by Dr. Ghaus Ur Rahman, Assistant Professor; Department of Mathematics & Statistics, University of Swat. The following members of the Board attended the meeting. However, Dr. Faiz Muhammad couldn't participate in the meeting due to his Post-Doctoral studies in China.

1.	In-charge, Dr. Amin Ur Rashid, Department of Applied Physical and Material Sciences, UoS	Convener
2.	Dr. Muneeb Ur Rahman, Associate Professor; Islamia College University, Peshawar	Member
3.	Mr. Afzal Khan, Associate Professor; GPG Jehanzeb College, Saidu Sharif Swat	Member
4.	Dr. Muhammad Umar, Assistant Professor; Institute of Chemical Sciences, UoS	Member
5.	Mr. Israr Ahmad, Assistant Professor; GPG Jehanzeb College, Saidu Sharif Swat	Member
6.	Mr. Fazal Karam, Assistant Professor; GPG Jehanzeb College, Saidu Sharif Swat	Member
7.	Dr. Kefayat Ullah, Assistant Professor; Department of Applied Physical & Material Sciences, UoS	Member
8.	Mr. Murad Ali, Lecturer GPG Jehanzeb College, Saidu Sharif Swat	Member
9.	Mr. Muhammad Babar Azam Khan, Lecturer; Department of Applied Physical and Material Sciences, UoS	Member

Dr. Amin Ur Rashid welcomed the members of the Board of studies. He thanked the honorable members for taking time out of their busy schedules and coming all the way from different parts to participate in the meeting. He also thanked all the faculty members of the Department of Applied Physical & Material Sciences for their devotion in achieving high standards in instructions and good quality in research.

Dr. Amin Ur Rashid briefed the members about the Department and the curricula adopted to improve the quality of Physics education. The members of the board were satisfied and praised the working and improvement of the department. The members of the Board gave the following recommendations for the smooth working of the Department:

THE BOARD APPROVED THE FOLLOWING AGENDA ITEMS

Item No. 1: BS-Program in Physics
Scheme of Study and Courses for BS-Physics (4-year) program for the session 2015-19 and onwards were presented to the board for approval.
Decision: The Board unanimously recommended the scheme of study and courses for BS-Physics program. **(Annexures "A -H")**

Item No.2: M.Sc. Program in Physics
Scheme of Study and Courses for M.Sc. Physics (2-year) semester system program for the session 2016-18 and onwards were presented to the Board for approval.
Decision: The Board unanimously recommended scheme of study and courses for M.Sc. Physics program. **(Annexures "I -L")**

Item No. 3: Eligibility Criteria
(i) BS-Physics (4-year) program for the Session 2015-19 and onwards
F.Sc. or equivalent with at least 45 % marks as well as in the subject of Physics

(ii) M.Sc. Physics (2 year) program
B.Sc. with Physics and Mathematics-A with at least 45% marks in the subject of Physics
Decision: The Board unanimously recommended the eligibility criteria for the BS-Physics (4-year) and M.Sc. Physics (2-year) programs.

GENERAL RECOMMENDATIONS

The following general recommendations has been suggested and approved by the board of studies members for the improvement of teaching practices at the Department of Applied Physical & Material Sciences.

1. It was decided that for each batch there may be an industrial/research trip, for the exposure of students to the advance labs in leading research institutes of the country.
2. The board unanimously agreed upon that the GOF and GRF courses may be shuffled within semesters depending upon the availability of the concerned teachers.
3. Dr. Muneeb Ur Rahman proposed to write the proper names of Mathematics courses instead of Mathematics (I to IV).
4. Mr. Murad Ali, suggested to include vector calculus chapter in Mathematical Methods of Physics-I and further proposed to include a GRF course for basic mathematics in semester first of BS Physics.
5. Dr. Muneeb Ur Rahman proposed to bring uniformity in lab marks distribution and modification in the codes of elective courses.
6. The board decided that the research project will be offered to those students of BS and M.Sc. Physics having CGPA 3.0 or above. While the rest will study an Elective Physics Major Course.
7. Dr. Kefayat Ullah suggested to change the name of differential equations to ordinary differential equations and proposed an optional course “Clay Science’’ in BS Physics.

   The meeting was concluded with the vote of thanks by the chair to all the participants.

MISSION STATEMENT OF THE DEPARTMENT

The Department of Applied Physical and Material Sciences have a mission to produce well trained graduates and researchers capable enough to address the future challenges both at regional and international levels. The Department aims to provide quality education in the subject so that the students will utilize the knowledge of Physics in practical life which will be beneficial for the society. Apart from quality teaching, our mission is to cultivate an enthusiastic research culture by establishing laboratories equipped with sophisticated research facilities and establishing strong collaborations with other national and international institutions.

VISION OF THE DEPARTMENT

We envision our department to play a leading role in both teaching as well as research and to produce graduates with the potential to serve the nation and humanity in the best possible way.

OBJECTIVES OF THE DEPARTMENT

Following are the primary objectives of the department.

- To build solid foundations in Physics through standard curriculum.
- To develop the problem solving and analytical skills of the students.
- To develop communication and social skills of the students, particularly the speaking and writing skills in English language.
- To prepare well-trained graduates and researchers capable enough to address the future challenges both at regional and international levels.

MISSION OF THE PHYSICS PROGRAMS OFFERED

The primary aim of starting BS-Physics and M.Sc. Physics programs is to impart students with a conceptual understanding of the fundamental principles of physics, natural laws and their interpretation, as well as mathematical formulation of the physical phenomena in nature. It is aimed to develop the critical skills of the students necessary for solving problems from their physical surroundings, also to develop their capability of analyzing, addressing and posing solutions to problems of natural importance. These Physics programs have been started with a mission to produce well trained graduates and researchers capable enough to address the future challenges both at regional and international levels.

OBJECTIVES OF THE PHYSICS PROGRAMS

The main educational objectives of BS (4-year) and M.Sc. (2-year) degree programs are:

1. To impart students with a conceptual understanding of the fundamental principles of physics, natural laws and their interpretation, as well as mathematical formulation of the physical phenomena in nature,
2. To develop critical skills necessary for solving unknown problems from our physical surroundings,
3. To develop the capability of analyzing, addressing and posing solutions to problems of natural importance and to instill a deep appreciation of the need for optimum utilization of natural resources and environment
4. To instill in students, the habit of independent thinking, deep inquiry, and motivation for self-education,
5. To sharpen our students' mathematical prowess making them capable of modelling, analyzing and predicting the behavior of physical processes,
6. To enhance our students skills in scientific communication and the ability to clearly present physics and science in simple and clear language,
7. To introduce students with the spirit of working in interactive groups with the necessary requirements of scientific and professional ethics,
8. To develop hands-on experience in different laboratory techniques, modern instrumentation,

9. To enhance student competence in the design and conduct of experiments and analysis and presentation of experimental data and results,
10. To provide an in-depth understanding of some specialized area of physics through the option of elective courses.
11. To equip students with the necessary skill set for pursuing careers in physics education, research and industry in government or private organizations.

EXPECTED OUTCOMES OF THE PHYSICS DEGREE PROGRAMS

Graduates of the physics program will be able to:

1. Explain the importance of physics and its techniques to solve real life problems and provide the limitations of such techniques and the validity of the results.
2. Propose new physics questions and suggest possible software packages and/or computer programming to find solutions to these questions.
3. Serve on physics based position/field jobs/teaching jobs.
4. Take interest for higher education in various areas of Physics and in other areas related to Physics
5. Identify fundamental concepts of Physics as applied to science and other areas of physics, and to interconnect the roles of pure and applied physics.

LAYOUT OF BS (4-YEAR) PHYSICS

Compulsory Requirements (the student has no choice)		General Courses to be chosen from other departments		Discipline Specific Foundation Courses	
9 Courses		**7-8 Courses**		**6-10 Courses**	
25 Credit Hours		**21-24 Credit Hours**		**20-24 Credit Hours**	
Subject	**Cr. Hr.**	**Subject**	**Cr. Hr.**	**Subject**	**Cr. Hr.**
1. English-I	3(3+0)	1. GOF-I	3(3+0)	1. Mechanics	4(4+0)
2. English-II	3(3+0)	2. GRF-I	3(3+0)	2. Waves and Oscillations	3(3+0)
3. English-III	3(3+0)	3. Linear Algebra	3(3+0)	3. Heat & Thermodynamics	3(3+0)
4. English-IV	3(3+0)	4. GOF-II	3(3+0)	4. Electricity & Magnetism	4(4+0)
5. Pakistan Studies	2(2+0)	5. GRF-II	3(3+0)	5. Modern Physics	3(3+0)
6. Islamic Studies	2(2+0)	6. GRF-III	3(3+0)	6. Optics	3(3+0)
7. Calculus-I	3(3+0)	7. Ordinary Differential Equations	3(3+0)	7. Lab-I	1(0+1)
8. Calculus-II	3(3+0)			8. Lab-II	1(0+1)
9. Introduction to Computing	3(3+0)			9. Lab-III	1(0+1)
				10. Lab-IV	1(0+1)
	25		**21**		**24**

Major courses including research project/internship		**Elective Courses within the major**	
15-18 Courses		**4 Courses**	
45-51 Credit hours		**12 Credit Hours**	
Subject	**Cr. Hr.**	**Subject**	**Cr. Hr.**
1. Quantum Mechanics – I	3(3+0)	1. Elective-l	3(3+0)
2. Quantum Mechanics – II	3(3+0)	2. Elective-II	3(3+0)
3. Classical Mechanics	3(3+0)	3. Elective-III	3(3+0)
4. Electronics I	3(3+0)	4. Elective–IV	3(3+0)
5. Electronics II	3(3+0)		
6. Mathematical Methods of Physics–I	3(3+0)		
7. Mathematical Methods of Physics–II	3(3+0)		
8. Electrodynamics-I	3(3+0)		
9. Electrodynamics-II	3(3+0)		
10. Statistical Physics	3(3+0)		
11. Nuclear Physics	3(3+0)		
12. Solid State Physics I	3(3+0)		
13. Solid State Physics II	3(3+0)		
14. Atomic and molecular physics	3(3+0)		
15. Research Project	3(3+0)		
16. Lab-V	2(0+2)		
17. Lab-VI	2(0+2)		
18. Lab-VII	2(0+2)		
	51		**12**

Total Credit Hours: 133

GOF = General Subjects from Faculties other than Sciences

GRF = General Subjects from Science Faculty

Notes:

- A total of two GOF and three GRF courses must be taken
- The order of Linear Algebra and Ordinary Differential Equations can be swapped
- The University can reshuffle the courses within semesters to suit their particular needs

NOTE:

Credit hours requirement for the award of BS-Physics degree 133-142

Credit hours requirement for the award of M.Sc-Physics degree 66-72

Annexure "A"

SCHEME OF STUDIES FOR BS PHYSICS (4-YEAR) PROGRAM

	Categories	No. of Courses	Credit Hours
C	Compulsory Requirements (no choice)	9	25
G	General Courses (to be chosen from other departments)	7-8	21-24
F	Discipline Specific Foundation Courses	6-10	20-24
M	Major Courses including research project	15-18	45-51
L	Lab courses	7	10
E	Electives	4-5	12-15
Total		48-51	133-142

ELIGIBILITY CRITERIA FOR BS-PHYSICS (4 YEAR) PROGRAM

F.Sc. or equivalent with at least 45 % marks as well as in the subject of Physics.
Note: The number of elective courses are 4 (four) for project students and the rest will take 5(five) courses.

SEMESTERWISE BREAKDOWN OF BS-PHYSICS COURSES

First Year

Semester-I

C. Code	Courses Title	Cr. Hr.	Remarks	PR/CR
ENG 101	English-I	3 (3-0)	Comp-1	----
MATH 102	Calculus-I	3 (3-0)	Comp-2	----
CS 103	Introduction to Computing	3 (3-0)	Comp-3	----
PHY 104	Mechanics	4 (4-0)	Found-1	----
STAT 105	Statistics-I	3 (3-0)	(GRF-I)	----
PHY 106L	Lab-I	1 (0-1)	Found-2	----
	Total Credit Hours	**17**		

Semester-II

C. Code	Courses Title	Cr. Hr.	Remarks	PR/CR
ENG 151	English-II	3 (3-0)	Comp-4	English-I
MATH 152	Calculus-II	3 (3-0)	Comp-5	Calculus-I
PHY 153	Electricity & Magnetism	4 (4-0)	Found-3	PHY-101, Calculus-I/ Calculus-II
PHY 154	Heat & Thermodynamics	3 (3-0)	Found-4	PHY-101/Calculus-II
CH 155	Chemistry-I	3 (3-0)	(GRF-II)	----
PHY 156L	Lab-II	1 (0-1)	Found-5	----
	Total Credit Hours	**17**		

Second Year

Semester-III

C. Code	Courses Title	Cr. Hr.	Remarks	PR/CR
ENG 201	English-III	3 (3-0)	Comp-6	English-II
MATH 202	Linear Algebra	3 (3-0)	Gen-3	Calculus-I&II
PHY 203	Waves & Oscillations	3 (3-0)	Found-6	PHY-101, Calculus-II
PHY 204	Modern Physics	3 (3-0)	Found-7	PHY-101, PHY-151
CS 205	Introduction to Programming for Physicists	3 (3-0)	(GRF-III)	Introduction to Computing
PHY 206L	Lab-III	1 (0-1)	Found-8	----
	Total Credit Hours	**16**		

Semester-IV

C. Code	Courses Title	Cr. Hr.	Remarks	PR/CR
ISL 251	Islamic Studies	2 (2-0)	Comp-7	----
ENG 252	English-IV	3 (3-0)	Comp-8	English-III
MATH 253	Ordinary Differential Equations	3 (3-0)	Gen-5	Linear Algebra
ECO 254	Introductory Economics	3 (3-0)	(GOF-I)	----
PHY 255	Optics	3 (3-0)	Found-9	PHY-201
MGT 256	Principles of Management	3 (3-0)	(GOF-II)	----
PHY 257L	Lab-IV	1 (0-1)	Found-10	
	Total Credit Hours	**18**		

Third Year

Semester-V

C. Code	Courses Title	Cr. Hr.	Remarks	PR/CR
PHY 301	Mathematical Methods of Physics-I	3 (3-0)	Maj-1	PHY-101, O.D.E, Linear algebra
PHY 302	Electrodynamics-1	3 (3-0)	Maj-2	PHY-151, Calculus-II
PHY 303	Classical Mechanics	3 (3-0)	Maj-3	PHY-101
PHY 304	Electronics-1	3 (3-0)	Maj-4	PHY-202
PS 305	Pak Study	2 (2-0)	Comp-9	----
PHY 306L	Lab-V	2 (0-2)	Maj-5	----
	Total Credit Hours	**16**		

Semester-VI

C. Code	Courses Title	Cr. Hr.	Remarks	PR/CR
PHY 351	Mathematical Methods of Physics-II	3 (3-0)	Maj-6	PHY-301
PHY 352	Quantum Mechanics-I	3 (3-0)	Maj-7	PHY-202
PHY 353	Electrodynamics-II	3 (3-0)	Maj-8	PHY-302
PHY 354	Electronics-II	3 (3-0)	Maj-9	PHY-304
PHY 355	Statistical Mechanics	3 (3-0)	Maj-10	PHY-152,Calculus-II, Statistic-I
PHY 356L	Lab-VI	2 (0-2)	Maj-11	----
	Total Credit Hours	**17**		

Fourth Year

Semester-VII

C. Code	Courses Title	Cr. Hr.	Remarks	PR/CR
PHY 401	Quantum Mechanics-II	3 (3-0)	Maj-12	PHY-352
PHY 402	Atomic & Molecular Physics	3 (3-0)	Maj-13	PHY-352/ PHY-401
PHY 403	Solid State Physics-I	3 (3-0)	Maj-14	PHY-352, PHY-355
PHY 404	Nuclear Physics	3 (3-0)	Maj-15	PHY-202
PHY 405	Elective	3 (3-0)	Elective	----
PHY 410L	Lab-VII	2 (0-2)	Maj-16	----
	Total Credit Hours	**17**		

Semester-VIII

C. Code	Courses Title	Cr. Hr.	Remarks	PR/CR
PHY 451	Solid State Physics-II	3 (3-0)	Maj-17	PHY-403
PHY 452	Elective	3 (3-0)	Elective	----
PHY 453	Elective	3 (3-0)	Elective	----
PHY 454	Elective	3 (3-0)	Elective	----
PHY 498	Research Project/Elective Course	3 (3-0)	Maj-18	----
	Total Credit Hours	**15**		

Note: Elective Course in (PHY-499) Means Physics Major Course

Minimum Degree Credit Hours= 133

Marks Breakdown for BS Courses

Item	Maximum Marks
Mid Term Examination	30%
Internal Marks (Assignments, Quizzes, Presentations)	20%
Final Term Examination	50%
Total	100%

Marks Breakdown for BS Labs (I- VII)

Item	Maximum Marks
Lab Report	20%
Practical/Viva	80%
Total	100%

Annexure "B"

RECOMMENDED CURRICULUM FOR BS PHYSICS (4 YEAR) PROGRAM

MECHANICS

Credit Hours: **4 (4-0)**
Course Code: **PHY 104**

Objectives:
The main objective of this course is to understand the different motions of objects on a macroscopic scale and to develop simple mathematical formalisms to analyze such motions. This is a calculus-based introductory course with maximum emphasis on applying the acquired knowledge to solving problems.
Learning Outcomes:
After studying this course, the student will understand the different motions of objects on a macroscopic scale and to develop simple mathematical formalisms to analyze such motions, and to lay the foundations for further studies in Physical Sciences and Engineering.

Week 1: Basic Concepts: Units and Dimensions, SI Units, Changing Units, Scalars and Vectors, Adding Vectors: Graphical as well as Component Method, Multiplying Vectors: Dot and Cross Products.
Week 2: Motion in One, Two and Three Dimensions: Position & Displacement, Velocity and Acceleration, Motion under Constant Acceleration, Projectile Motion.
Week 3: Uniform Circular Motion, Relative Velocity and Acceleration in One and Two Dimensions, Inertial and Non-Inertial reference frames.
Week 4: Newton's Laws: Newton's Laws of Motion and their Applications involving some particular forces including Weight.
Week 5: Normal Force, Tension, Friction, and Centripetal Force, Newton's Law of Gravitation, Gravitational Potential Energy, Escape Velocity, Kepler's Laws, Satellite Orbits & Energy.
Week 6: Work and Kinetic Energy: Work done by Constant and Variable Forces: Gravitational and Spring Forces, Power, Conservative and Non-conservative Forces, Work and Potential Energy
Week 7: Isolated Systems and Conservation of Mechanical Energy, Work Done by External Forces including Friction and Conservation of Energy.
Week 8: System of Particles, Motion of a System of Particles and Extended Rigid Bodies, Center of Mass and Newton's Laws for a System of Particles.
Week 9: Linear Momentum, Impulse, Momentum & Kinetic Energy in One and Two-Dimensional Elastic and Inelastic Collisions.
Week 10: Rotational Motion Rotation about a Fixed Axis, Angular Position, Angular Displacement

Week 11: Angular Velocity and Angular Acceleration, Rotation under Constant Angular Acceleration, relationship between Linear and Angular Variables.
Week 12: Rotational Inertia, Parallel-axis Theorem, Torque and Newton's Law for Rotation, Work and Rotational Kinetic Energy, Power, Rolling Motion.
Week 13: Angular Momentum for a single Particle and a System of Particles, Conservation of Angular Momentum Precession of a Gyroscope.
Week 14: Static Equilibrium involving Forces and Torques, Determination of moment of inertia of various shapes i.e. for disc, bar and solid sphere.
Week 15: Angular Momentum, Angular Velocity, Conservation of angular momentum, effects of Torque and its relation with angular momentum.
Week 16: Simple Harmonic Motion (SHM): Amplitude, Phase, Angular Frequency, Velocity and Acceleration in SHM, Linear and Angular Simple Harmonic Oscillators, Energy in SHM, Simple Pendulum, Physical Pendulum, SHM and Uniform Circular Motion, Damped Harmonic Oscillator.

Recommended Books:
1. D. Halliday, R. Resnick and J. Walker, "Fundamentals of Physics", John Wiley & Sons, 9th ed. 2010.
2. R. A. Serway and J. W. Jewett, "Physics for Scientists and Engineers", Golden Sunburst Series, 8th ed. 2010.
3. R. A. Freedman, H. D. Young, and A. L. Ford (Sears and Zeemansky), "University Physics with Modern Physics", Addison-Wesley-Longman, 13th International ed. 2010.
4. F. J Keller, W. E. Gettys and M. J. Skove, "Physics: Classical and Modern, McGraw Hill. 2nd ed. 1992.
5. D. C. Giancoli, "Physics for Scientists and Engineers, with Modern Physics", Addison-Wesley, 4th ed. 2008.

ELECTRICITY AND MAGNETISM

Pre-requisite: **Mechanics, Calculus-I**
Co-requisite: **Calculus-II**
Credit Hours: **4 (4-0)**
Course Code: **PHY 153**

Objectives:
The main objective of this course is to understand the Physics of Electromagnetism and to develop simple mathematical formalisms to analyze the electromagnetic fields and interactions. This is a calculus-based introductory course with maximum emphasis on applying the acquired knowledge to solving problems.
Learning Outcomes:

After studying this course, the students will understand the Physics of Electromagnetism and to develop simple mathematical formalisms to analyze the electromagnetic fields and interactions, and to lay the foundations for further studies in Physical Sciences and Engineering.

Week 1: Electrostatics Electric Charge, Conductors and Insulators, Coulomb's Law, Electric Fields due to a Point Charge and an Electric Dipole, Electric Field due to a Charge Distribution, Electric Dipole in an Electric Field, Electric Flux
Week 2: Gauss' Law and its Applications in Planar, Spherical and Cylindrical Symmetry.
Week 3: Electric Potential, Equipotential Surfaces, Potential due to a Point Charge and a Group of Point Charges, Potential due to an Electric
Week 4: Dipole, Potential due to a Charge Distribution, Relation between Electric Field and, Electric Potential Energy.
Week 5: Capacitors and Capacitance, Parallel Plate, Cylindrical and Spherical capacitors, Capacitors in Series and Parallel, Energy Stored in an Electric Field, Dielectrics and Gauss' Law
Week 6: DC Circuits, Electric Current and Current Density, Resistance and Resistivity, Ohm's Law,
Week 7: Power in Electric Circuits, Semiconductors and Superconductors, Work, Energy, and EMF, Resistances in Series and Parallel,
Week 8: Single and Multi-loop Circuits, Kirchhoff's Rules, RC Circuits, Charging and Discharging of a Capacitor.
Week 9: Magnetic Field and Magnetic Force, Crossed Electric and Magnetic Fields and their Applications, Hall Effect,
Week 10: Magnetic Force on a Current Carrying Wire, Torque on a Current Loop, Magnetic
Week 11: Dipole Moment, Magnetic Field Due to a Current, Force between two Parallel Currents, **Week 12:** Ampere's Law, Biot-Savart Law: Magnetic Field due to a Current, Long Straight Wire carrying Current, Solenoids and Toroids,
Week 13: A current-carrying Coil as a Magnetic Dipole, Inductance, Faraday's Law of Induction, Lenz's Law, Induction and Energy Transfers, Induced Electric Fields, Inductors and Inductances, Self-Inductance,
Week 14: RL Circuits, Energy Stored in a Magnetic Field, Energy Density, Mutual Induction.
Week 15: Alternating Fields and Currents: LC Oscillations, Damped Oscillations in an RLC circuit, Alternating Currents, Forced Oscillations, Resistive, Capacitive, and Inductive Loads, **Week 16:** RLC series Circuit, Power in AC Circuits, Transformers, Gauss' Law for Magnetism, Induced Magnetic Fields Displacement Current, Spin & Orbital Magnetic Dipole Moment, Diamagnetism, Paramagnetism, Ferromagnetism, Hysteresis.

Recommended Text Books:

1. D. Halliday, R. Resnick and J. Walker, "Fundamentals of Physics", John Wiley & v Sons, 9th ed. 2010.
2. R. A. Serway and J. W. Jewett, "Physics for Scientists and Engineers", Golden

Sunburst Series, 8th ed. 2010.
3. R. A. Freedman, H. D. Young, and A. L. Ford (Sears and Zeemansky), "University Physics with Modern Physics", Addison-Wesley-Longman, 13th International ed. 2010
4. F. J Keller, W. E. Gettys and M. J. Skove, "Physics: Classical and Modern, McGraw Hill. 2nd ed. 1992.
5. D. C. Giancoli, "Physics for Scientists and Engineers, with Modern Physics", Addison-Wesley, 4th ed. 2008.

HEAT AND THERMODYNAMICS

Pre-requisites: **Mechanics**
Co-requisites: **Calculus-II**
Credit Hours: **3 (3-0)**
Course Code: **PHY 154**

Objective(s):
To understand the fundamentals of heat and thermodynamics.

Learning Outcomes:
After studying this course the students will be able to understand the fundamentals of heat and thermodynamics. And to lay the foundations for further studies in Physical Sciences and Engineering.

Week 1: Basic Concepts and Definitions in Thermodynamics: Thermodynamic system, Surrounding and Boundaries. Type of systems. Macroscopic and microscopic description of system. Properties and state of the substance:
Week 2: Extensive and Intensive properties, Equilibrium, Mechanical and Thermal Equilibrium. Processes and Cycles: Isothermal, Isobaric and Isochoric.
Week 3: The state of the system at Equilibrium, Heat and Temperature, Temperature, Kinetic theory of ideal gas,
Week 4: Work done on an ideal gas, Review of previous concepts. Internal energy of an ideal gas:
Week 5: Equipartition of Energy, Intermolecular forces, Qualitative discussion,
Week 6: The Virial expansion, The Van der Waals equation of state.
Week 7: Thermodynamics, First law of thermodynamics and its applications to adiabatic, isothermal
Week 8: Cyclic and free expansion. Reversible and irreversible processes. Second law of thermodynamics

Week 9: Carnot theorem and Carnot engine. Heat engine, Refrigerators. Calculation of efficiency of heat engines.
Week 10: Thermodynamic temperature scale: Absolute zero, Entropy, Entropy in reversible process
Week 11: Entropy in irreversible process. Entropy and Second law of thermodynamics, Entropy and Probability.
Week 12: Thermodynamic Functions, Thermodynamic functions Internal energy Enthalpy,
Week 13: Gibb's functions, Entropy, Helmholtz functions
Week 14: Maxwell's relations, TdS equations, Energy equations and their applications.
Week 15: Low Temperature Physics, Joule-Thomson effect and its equations. Thermoelectricity:
Week 16: Thermocouple, Seabeck's effect, Peltier's effect, Thomson effect.

Recommended Books:

1. D. Halliday, R. Resnick and K. Krane, "Physics", John Wiley, 5th ed. 2002.
2. D. Halliday, R. Resnick and J. Walker, "Fundamentals of Physics", John Wiley, 9th ed. 2010.
3. M. W. Zemansky, "Heat and Thermodynamics", Mc Graw Hill, 7th ed. 1997.
4. M. Sprackling, "Thermal Physics" McMillan 1991.
5. B. N. Roy, "Principle of Modern Thermodynamics", Institute of Physics, London 1995.

WAVES AND OSCILLATIONS

Pre-requisites: **Mechanics, Calculus II**
Credit Hours: **3 (3-0)**
Course Code: **PHY 203**
Objective(s):
To develop a unified mathematical theory of oscillations and waves in physical systems.
Learning Outcomes:
After Studying this course, the students will learn to develop a unified mathematical theory of oscillations and waves in physical systems. And to lay the foundations for further studies in Physical Sciences and Engineering.

Week 1: Introduction to basic concepts, Simple and Damped Harmonic Oscillation
Week 2: Mass-Spring System, Simple Harmonic Oscillator Equation
Week 3: Complex Number Notation, LC Circuit, Simple Pendulum, Quality Factor, LCR circuit.
Week 4: Forced Damped Harmonic Oscillation: Steady-State Behavior, Driven LCR Circuit
Week 5: Transient Oscillator Response, Resonance, Coupled Oscillations
Week 6: Coupled Oscillations, Two Spring-Coupled Masses, Two Coupled LC Circuits
Week 7: Three Spring Coupled Masses, Normal Modes, Atomic and Lattice Vibrations.
Week 8: Transverse Waves: Transverse Standing Waves, Normal Modes, General Time Evolution of a Uniform String,

Week 9: Phase velocity, Group Velocity. Longitudinal Waves, Spring Coupled Masses, Sound Waves in an Elastic
Week 10: Solid, Sound Waves in an Ideal Gas. Traveling Waves, Standing Waves in a Finite Continuous Medium, Traveling
Week 11: Waves in an Infinite Continuous Medium, Energy Conservation, Transmission, Lines,
Week 12: Reflection and Transmission at Boundaries, Electromagnetic Waves.
Week 13: Wave Pulses, Fourier series and Fourier Transforms, Bandwidth,
Week 14: Heisenberg's Uncertainty Principle, Multi-Dimensional Waves, Plane Waves
Week 15: Three-Dimensional Wave Equation, Laws of Geometric Optics, wave guides.
Week 16: Cylindrical Waves. Interference and Diffraction of Waves: Double-Slit Interference, Single-Slit Diffraction.

Recommended Books:

1. J. Pain, "The Physics of Vibrations and Waves", John Wiley, 6th ed. 2005.
2. P. French, "Vibrations and Waves", CBS Publishers (2003).
3. F. S. Crawford, Jr., "Waves and Oscillations", Berkeley Physics Course, Vol. 3, McGraw-Hill, 1968.
4. A. Hirose, and K. E. Lonngren, "Introduction to Wave Phenomena", Krieger Publications, 2003.

MODERN PHYSICS

Pre-requisites: **Mechanics, Electricity and Magnetism**
Credit Hours: **3 (3-0)**
Course Code: **PHY 204**
Objective(s):
To understand the non-classical aspects of Physics, the emphasis is on the applications of uantum Physics in microscopic-scale Physics, atomic and molecular structure and processes.
Learning Outcomes:
After studying this course, the students will learn to understand the non-classical aspects of Physics and will provide them an initial plat form for core courses, Quantum mechanics, Atomic Physics and nuclear Physics.

Week 1: Motivation for Non--Classical Physics, Quantum interference, blackbody radiation and ultraviolet catastrophe.
Week 2: Planck's quantization. Wace-Particle Duality, Photoelectric effect, Compton effect,
Week 3: Production and properties of X-rays, diffraction of X-rays, concept of matter waves, de Broglie relationship.
Week 4: electrons are waves, electron diffraction, particulate nature of matter, contributions of Faraday (atoms exist)
Week 5: Thomson (electron exists), Rutherford (nucleus exists) and Bohr (quantization of energies inside an atom)

Week 6: Wave packets and wave groups, dispersion, Heisenberg Uncertainty Principle
Week 7: Direct confirmation of quantization through Franck-Hertz experiment and spectroscopy, working of electron microscopes.
Week 8: Special Theory of Relativity, Inertial and non-inertial frame, Postulates of Relativity, The Lorentz Transformation, Derivation
Week 9: Assumptions on which inverse transformation is derived, Consequences of Lorentz transformation
Week 10: Relativity of time, Relativity of length, Relativity of mass, Transformation of velocity
Week 11: Variation of mass with velocity, mass energy relation and its importance, relativistic momentum and Relativistic energy.
Week 12: From Atoms to Molecules and Solids: Ionic bonds, covalent bonds, hydrogen bonds, molecular orbitals
Week 13: How crystals are different from amorphous solids. Why and how do metals conduct electricity. Introduction to Nuclear Structure. Radii, Isotopes, etc
Week 14: Bands in solids, semiconductors, introduction to LED's and lasers, introducing grapheme.
Week 15: Quantum Mechanics in One Dimension, The concept of a wave function, time independent Schrodinger equation and interpretation of the equation
Week 16: solving the Schrodinger equation for a free particle, for a particle inside an infinite box, relationship between confinement and quantization, working of a CCD camera.

Recommended Books:

1. R.A. Serway, C.J. Moses and C.A. Moyer, "Modern Physics", Brooks Cole, 3rd ed. 2004.
2. Paul A. Tipler and Ralph A. Llewellyn, "Modern Physics", W H Freeman and Company 6th ed. 2012.
3. Arthur Beiser, "Concepts of Modern Physics", McGraw-Hill, 6th ed. 2002.
4. R. M. Eisberg and R. Resnick, "Quantum Physics of Atoms, molecules, Solids, Nuclei and Particles", John Wiley, 2nd ed. 2002.

OPTICS

Pre-Requisites:	**Waves and Oscillations**
Credit Hours:	**3(3-0)**
Course Code:	**PHY 255**

Objective(s):
To understand the optical phenomena and their uses in physical systems.
Learning Outcomes:
After studying this course the students will learn to understand the optical phenomena and their uses in physical systems.

Week 1: Introduction to basic definition of lenses and its geometry, Propagation of Light
Week 2: Image Formation, Huygens' Principle, Fermat's Principle, Laws of Reflection and Refraction,
Week 3: Refraction at a Spherical Surface, Thin Lenses, Newtonian Equation for a Thin Lens.
Week 4: Matrix Methods in Paraxial Optics, Ray Transfer Matrices, Thick Lens,
Week 5: Significance of System Matrix Elements, Cardinal Points of an Optical System with examples
Week 6: Optical Instruments including Simple Magnifiers, Telescopes and Microscopes, Chromatic and Monochromatic Aberrations
Week 7: Spherical Aberrations, Coma, Distortion, Stops, Pupils, Windows.
Week 8: Superposition & Interference, Standing Waves, Beats, Phase and Group Velocities
Week 9: Two-Beam and Multiple-Beam Interference, Thin Dielectric Films, Michelson and Fabry-Perot Interferometers
Week 10: Resolving Power, Free-Spectral Range. Polarization
Week 11: Polarization Jones Matrices, Production of Polarized Light, Dichroism, Brewster's Law, Birefringence, Double Refraction.
Week 12: Fraunhofer Diffraction, from a Single Slit, Rectangular and Circular Apertures, Double Slit, Many Slits, Diffraction Grating
Week 13: Dispersion, Resolving Power Blazed Gratings. Fresnel Diffraction, Zone Plates,
Week 14: Rectangular Apertures, Cornu's Spiral. Coherence & Holography**,**
Week 15: Temporal Coherence, Spatial Coherence, Holography of a Point object and an Extended Object.
Week 16: Laser Basics: Stimulated Emission, Population Inversion, Resonators, Threshold and Gain, Multi-layered Dielectric Films.

Recommended Books:

1. F. Pedrotti, L. S. Pedrotti and L. M. Pedrotti, "Introduction to Optics", Pearson Prentice Hall, 3rd ed. 2007.
2. E. Hecht and A. Ganesan, "Optics", Dorling Kindersley, 4th ed. 2008.
3. M. V. Klein and T. E. Furtak, "Optics", John Wiley, 2nd ed. 1986.
4. K. K Sharam, "Optics: Principles and Applications", Academic Press, 2006.
5. C. A. Bennett, "Principles of Physical Optics", John Wiley, 2008.

MATHEMATICAL METHODS OF PHYSICS-I

Pre-requisite:	**Mechanics, Differential Equations, Linear Algebra**
Credit Hours:	**3 (3-0)**
Course Code:	**PHY 301**

Objective(s):

To develop the mathematical background of student in vectors, tensors, matrices and some of their uses in the world of physics, to give basic understanding of group theory and complex variables used in physics.

Learning Outcomes:

After Studying this course the students will learn to develop the mathematical background in vectors, tensors, matrices, group theory and some of their uses in the world of Physics.

Week 1: Vector Analysis, Ordinary Derivatives of vector valued functions, Continuity and differentiability

Week 2: Partial derivative of vectors, Differential geometry, Ordinary Integrals of vector valued function

Week 3: Line integrals, surface integrals, Volume Integrals, The Divergence theorem of Gauss, Stoke's theorem

Week 4: Green's theorem in the plane, Transformation of coordinates, Orthogonal Curvilinear Coordinate

Week 5: Unit vectors in curvilinear system, Arc length and volume element, Gradient, divergence and Curl.

Week 6: Special orthogonal coordinate system, Cylindrical coordinates, Spherical coordinate systems.

Week 7: Partial Differential Equations, Introduction to important PDEs in Physics (wave equation, diffusion equation, Poisson's equation, Schrodinger's equation)

Week 8: General form of solution, general and particular solutions (first order, inhomogeneous, second order)

Week 9: characteristics and existence of solutions, uniqueness of solutions, separation of variables

Week 10: Cartesian coordinates, superposition of separated solutions, General Solution

Week 11: Separation of variables in curvilinear coordinates, integral transform methods, Green's functions.

Week 12: Complex Analysis, Review (polar form of complex numbers and de Moivre's theorem, complex logarithms and powers),

Week 13: functions of a complex variable, Cauchy-Riemann conditions, power series in a complex variable and analytic continuation with examples

Week 14: Multi-valued functions and branch cuts, singularities and zeroes of complex functions, complex integration

Week 15: Cauchy's theorem, Cauchy's integral formula, Laurent series and residues

Week 16: Residue integration theorem, definite integrals using contour integration.

Recommended Books:

1. G. Arfken, H. J. Weber, and F. E. Harris, "Mathematical Methods for Physicists", Academic

Press, 7th ed. 2012.
2. K. F. Riley, M. P. Hobson, S. J. Bence, “Mathematical Methods for Physicists”, Cambridge University Press, 2006.
3. E. Kreyszig, “Advanced Engineering Mathematics”, John Wiley, 8th ed. 1999.
5. Vector analysis, by Murray Spiegel. McGraw Hill

ELECTRODYNAMICS-I

Pre-requisites: **Electricity and Magnetism, Calculus-II**
Credit Hours: **3 (3-0)**
Course Code: **PHY 302**

Objective(s):
To understand the basic ideas of electromagnetism and the phenomenon’s associated with Electric and Magnetic fields.
Learning Outcomes: After studying this subject, the student will learn to understand the basic ideas of electromagnetism and the phenomenon’s associated with Electric and Magnetic fields.

Week 1: Review of Calculus, vector algebra and calculus, Cartesian coordinates spherical coordinates.
Week 2: The Dirac Delta Function, Review of vector calculus using example of Dirac Delta function, the divergence of r/r^2, the one-dimensional and the three dimensional
Week 3: Dirac delta functions. The theory of vector fields, the Helmholtz theorem, potentials. Electrostatics, The electric field: introduction, Coulomb’s law, the electric field, continuous charge distributions.
Week 4: Divergence and curl of electrostatic fields: field lines, flux and Gauss’s law, the divergence of E, applications of Gauss’s law, the curl of E. Electric potential, introduction to potential, comments on potential
Week 5: Poisson’s equation and Laplace’s equation, the potential of a localized charge distribution, summary, electrostatics boundary conditions, Work and energy in electrostatics,
Week 6: The work done to move a charge, the energy of a point charge distribution, the energy of a continuous charge distribution, Comments on electrostatic energy. Conductors, basic properties, induced charges, surface charge and the force on a conductor, capacitors.
Week 7: Special Techniques, Laplace’s equation: introduction, Laplace’s equation in one, two and three dimensions,
Week 8: boundary conditions and uniqueness theorems, conductors and second uniqueness theorems.
Week 9: The Method of Images: The classic image problem, induced surface charge, force and energy, other image problems.

Week 10: Multi-pole Expansion, Approximate potential at large, the monopole and dipole terms, origin of coordinates in multi-pole, expansions, the electric field of a dipole.
Week 11: Electric Fields in Matter, Polarization: dielectrics, induced dipoles, alignment of polar molecules, polarization. The field of a polarized object: bound charges, physical interpretation of bound charges and the field inside a dielectric.
Week 12: The electric displacement: Gauss's law in the presence of dielectrics, a deceptive parallel, boundary conditions. Linear Dielectrics: susceptibility, permittivity, dielectric constant, boundary value problems with linear dielectric energy in dielectric systems
Week 13: Magnetostatics, The Lorentz Force law, magnetic fields, magnetic forces, currents. The Biot-Savart Law: steady currents, the magnetic field of a steady current. The divergence and curl of B: straight-line currents,
Week 14: the divergence and curl of B, applications of Ampere's law, comparison of magnetostatics and electrostatics. Magnetic Vector Potential: the vector potential, summary, magnetic boundary conditions, multi-pole expansion of the vector potential.
Week 15: Magnetic Fields in Matter, Magnetization, diamagnets, paramagnets, ferromagnets, torques and forces on magnetic dipoles, effect of a magnetic field on atomic orbits, magnetization. The Field of a Magnetized Object
Week 16: bound currents, physical interpretation of bound currents, and the magnetic field inside matter. The auxiliary field H: Ampere's law in magnetized materials, a deceptive parallel, boundary conditions. Linear and nonlinear media: magnetic susceptibility and permeability, ferromagnetism.

Recommended Books:

1. D. J. Griffiths, "Introduction to Electrodynamics", Prentice Hall, 3rd ed. 1999.
2. M. N. O. Sadiku, "Elements of Electromagnetics", Oxford University Press, 5th ed. 2009.
3. F. Melia, "Electrodynamics", University of Chicago Press, 2001.
4. Hearld J and W. Muller-Kristen, "Electrodynamics", World Scientific Publishing, 2nd ed. 2011.

CLASSICAL MECHANICS

Pre-requisites: **Mechanics**
Credit Hours: **3 (3-0)**
Course Code: **PHY 303**
Objective(s):
To develop the basic knowledge of classical world using the laws of Physics. The various formulations of classical mechanics will help to develop the understanding of various branches of Physics.
Learning Outcomes: After studying this subject, the student will learn to understand the basic ideas and formulations of Classical Mechanics.

Week 1: Review of Newtonian Mechanics, Frame of reference, orthogonal transformations,
Week 2: Angular velocity and angular acceleration, Newton's laws of motion, Galilean transformation, conservation laws,
Week 3: systems of particles, motion under a constant force, motions under variable force, time-varying mass system.
Week 4: The Lagrange Formulation of Mechanics and Hamilton Dynamics.
Week 5: Generalized co-ordinates and constraints, D'Alembert principle and Lagrange's Equations,
Week 6: Hamilton's principle, integrals of motion, non-conservative system and generalized potential,
Week 7: Lagrange's multiplier method, the Hamiltonian of a dynamical system,
Week 8: Canonical equations, canonical transformations, Poisson brackets, phase space and Liouville's theorem.
Week 9: Central Force Motion, The two-body problem, effective potential and classification of orbits, Kepler's laws,
Week 10: Stability of circular orbits, hyperbolic orbits and Rutherford scattering,
Week 11: Center of mass co-ordinate system, scattering cross-sections.
Week 12: Motion in Non-inertial Systems, Accelerated translational co-ordinate system,
Week 13: Dynamics in rotating co-ordinate system, motion of a particle near the surface of the earth.
Week 14: The Motion of Rigid Bodies, The Euler angles, rotational kinetic energy and angular momentum, the inertia tensor.
Week 15: Euler equations of motion, motion of a torque-free symmetrical top.
Week 16: Stability of rotational motion.

Recommended Books:

1. T. L. Chow, "Classical Mechanics", John Wiley, 1995.
2. T. Kibble and F. Berkshire, "Classical Mechanics", World Scientific, 5th ed. 2004.

ELECTRONICS-I

Pre-requisites: **Modern Physics**
Credit Hours: **3 (3-0)**
Course Code: **PHY 304**

Objective(s):

The main objective of this course is to enable the students to understand the construction operation and modeling of semiconductor devices, and to inculcate in them the ability to analyze and design various electronic circuits.

Learning Outcomes: After studying this subject, the student will learn to understand the construction operation and modeling of semiconductor devices and to inculcate in them the ability to analyze and design various electronic circuits.

Week 1: The Semiconductor Diode: Metals, insulators and semiconductors, Conduction in Silicon and Germanium, The forbidden energy gap, n and p type semiconductors,
Week 2: the junction diode, diode voltage-current equation, Zener diodes, light emitting diodes, photodiodes, capacitance effects in the pn junction.
Week 3: The Diode as Rectifier and Switch, The ideal diode model, the half wave rectifier, the full wave rectifier, the bridge rectifier, measurement of ripple factor in the rectifier circuit,
Week 4: the capacitor filter, the ∏ filter, the ∏-R filter, the voltage doubling rectifier circuit, rectifying AC voltmeters, diode wave clippers, diode clampers.
Week 5: Circuit Theory and Analysis, Superposition theorem, Thevenin's Theorem, Norton's Theorem, Model for circuit, one port and two-port network,
Week 6: Hybrid parameter equivalent circuit, Power in decibels, The Junction Transistor as an Amplifier:
Week 7: Transistor voltage and current designations, the junction transistors, the volt-ampere curve of a transistor, the current amplification factors,
Week 8: the load line and Q point, the basic transistor amplifiers, the common emitter amplifier,
Week 9: the trans-conductance gm, performance of a CE amplifier, relation between Ai and Av, the CB amplifier, the CC amplifier, comparison of amplifier performance.
Week 10: DC Bias for the Transistor, Choice of Q point, variation of Q point, fixed transistor bias,
Week 11: The four-resistor bias circuit, design of a voltage feedback bias circuit, Common emitter, common collector, common base biasing.
Week 12: Field Effect Transistor, What is /field effect transistor, JFET: Static characteristics of JFET,
Week 13: Metal oxide semiconductor Field Effect Transistor (MOSFET of IGFET): enhancement and depletion mode,
Week 14: FET biasing techniques, Common drain, common source and common gate, fixed bias and self-bias configurations, Universal JFET bias curve, Darlington pair.
Week 15: Operational Amplifiers, The integrated amplifier, the differential amplifier, common mode rejection ratio, the operational amplifier.
Week 16: Summing operation, integration operation, comparator, milli-voltmeter.

Recommended Books:

1. Thomas L. Floyd, "Electronics Fundamentals: Circuits, Devices and Applications", Prentice Hall, 8th ed., 2009.
2. Electronic devices and circuit theory, Book by Louis Nashelsky and Robert Boylestad, Latest Edition.

2. B. Grob, “Basic Electronics”, McGraw-Hill, Tch ed. 1997.
3. B. Streetman and S. Banerjee “Solid State Electronics Devices”, Prentice Hall, 6th ed. 2005.
4. A. Bar-lev, “Semiconductor and Electronics Devices”, Prentice Hall, 3rd ed. 1993.
5. D. H. Navon and B. Hilbert, “Semiconductor Micro-devices and Materials”, CBS College Publishing, 1986.
6. A. P. Malvino, “Electronic Principles”, McGraw-Hill, 7th ed. 2006.
7. R. T. Paynter, “Introductory Electric Circuits”, Prentice Hall, 1998.

MATHEMATICAL METHODS OF PHYSICS-II

Pre-requisite:	**Mathematical Methods of Physics-II**
Credit Hours:	**3 (3-0)**
Course Code:	**PHY 351**

Objective(s)
To give the clear understanding of special functions, Fourier series, Fourier Transforms, Legendre functions and other orthogonal functions.
Learning Outcomes: After studying this subject, the student will learn to understand the advanced mathematical tools to solve various problems in advanced Physics and Engineering courses.

Week 1: Fourier series, Fourier series, Dirichlet conditions, Odd and even functions,

Week 2: half range Fourier sine or cosine series, complex notations for Fourier series,

Week 3: Orthogonal functions. The Fourier integral, Equivalent forms of Fourier’s integral theorem, Parseval’s identities for Fourier integrals.

Week 4: Gamma, Beta and other Special functions, The Gamma function and its graphical representations, Asymptotic formula for gamma function,

Week 5: The Beta function, Dirichlet integrals, Other Special functions, Error function,

Week 6: Exponential integrals, Fresnel sine and cosine integrals, asymptotic series or expansions.

Week 7: Bessel Functions, Bessel differential equation. Bessel functions of the first kind.

Week 8: Miscellaneous Problems

Week 9: Bessel’s Functions of the second kind, Generating functions for the Bessel function,

Week 10: Recurrence formulas, Functions related to Bessel’s function,

Week 11: Asymptotic formulas for Bessel’s functions, Series of Bessel’s function.

Week 12: Legendre Function and Other Orthogonal Functions, Legendre's differential equation, Legendre Polynomials.

Week 13: Generating function for Legendre Polynomials, recurrence formulas.

Week 14: Legendre functions of the first kind, Orthogonality of Legendre polynomials,

Week 15: Series expansion of Legendre Polynomials. Associated Legendre Functions. Hermit Polynomials.

Week 16: Miscellaneous Problems

Recommended Books:

1. Arfken G.B and H.J Weber, F.E Harris, 2012, 7th Edition, Mathematical Methods for Physicists, A. Press, New York.

2. Dass H.K, R. Verma, 2011, 6th Edition, Mathematical Physics, S. Chand& Company Ltd. New Delhi.

3. Kreyszig E. 2011, 10th Edition, Advanced Engineering Mathematics. Wiley, New York.

4. Collins R.E, 2011, 2nd Edition, Mathematical Methods for Physicists and Engineers, Dover Publications.

QUANTUM MECHANICS-I

Pre-requisites: **Modern Physics**

Credit Hours: **3 (3-0)**

Course Code: **PHY 352**

Objective(s)

To give the understanding of quantum mechanical solutions to various physical system such as harmonic oscillator etc.

Learning Outcomes: After studying this subject, the student will learn quantum mechanical solutions to various physical system such as harmonic oscillator etc.

Week 1: Waves and Particles: Introduction to the fundamental ideas of quantum mechanics Electromagnetic waves and photon, material particles and matter waves, quantum description of a particle,

Week 2: Wave packets, particle in a time-independent scalar potential, order of magnitude of the wavelength associated with material particles, constraints imposed by uncertainty relations,

Week 3: One-dimensional Gaussian wave packet: Spreading of the wave packet, stationary states of a particle in one-dimensional square potential, behavior of a wave packet at a potential step. The Mathematical Tools of Quantum Mechanics, One-particle wave function space, state space, Dirac notation, representations in the state space, observable,

Week 4: Representations, review of some useful properties of linear operators, unitary operators, study of the and representations, some general properties of two observable, Q and P, whose commutator is equal to iħ, the two-dimensional infinite well.

Week 5: The Postulates of Quantum Mechanics, Statement of the postulates and their physical interpretation, the physical implications of the Schrodinger equation, the superposition principle, particle in an infinite potential well,

Week 6: Study of the probability current in some special case, root-mean-square deviations of two conjugate observables, the density and evolution operators, Schrodinger and Heisenberg pictures, Gauge invariance,

Week 7: Bound states of a particle in a potential well of arbitrary shape, unbound states of a particle in the presence of a potential well or barrier of arbitrary shape, quantum properties of a particle in a one-dimensional periodic structure.

Week 8: Application of The Postulates to Simple Cases, Spin ½ And Two-Level Quantum Systems: Spin ½ particles, quantization of the angular momentum, illustration of the postulates in the case of a spin ½, general study of two level systems,

Week 9: Pauli matrices, diagonalization of a 2×2 Hermitian matrix, System of two spin ½ particles, Spin ½ density matrix, and Spin ½ particles in a static magnetic field and a rotating field, Magnetic resonance.

Week 10: The One-Dimensional Harmonic Oscillator, Importance of the harmonic oscillator in physics, eigenvalues and eigenstates of the Hamiltonian, mean value and root-mean-square deviations of X and P in state | , Some examples of harmonic oscillators,

Week 11: Study of the stationary states in the representation, Hermite polynomials, solving the Eigenvalues of the harmonic oscillators by the polynomial method, study of the stationary states in the representation, isotropic three-dimensional harmonic oscillator, charged harmonic oscillator placed in a uniform electric field, coherent states,

Week 12: Normal vibrational modes of coupled harmonic oscillators, vibrational modes of an infinite linear chain of coupled harmonic oscillators, phonons, one-dimensional harmonic oscillator in thermodynamics equilibrium at a temperature T.

Week 13: General Properties of Angular Momentum in Quantum Mechanics, concept of angular momentum in quantum mechanics, commutation relations, application to orbital angular momentum, spherical harmonics, rotation operators, rotation of diatomic molecules, angular momentum of stationary states of a two-dimensional harmonic oscillator, charged particle in a magnetic field and Landau levels.

Week 14: Particle in a Central Potential, The Hydrogen atom, Stationary states of a particle in a central potential, motion of the center of mass and relative motion for a system of two interacting particles,

Week 15: Hydrogen atom, Hydrogen like systems, A solvable example of a central potential: the isotropic three-dimensional harmonic oscillator, probability currents associated with the stationary states of the hydrogen atom,

Week 16: The hydrogen atom placed in a uniform magnetic field, para-magnetism and diamagnetism, Zeeman effect, study of some atomic orbitals, vibrational-rotational levels of diatomic molecules.

Recommended Books:

1. D.J. Griffiths, "Introduction to Quantum Mechanics", Addison-Wesley, 2nd ed. 2004.R.
2. Liboff, "Introductory Quantum Mechanics", Addison-Wesley, 4 ed. 2002.
3. N. Zettili, "Quantum Mechanics: Concepts and Applications", John Wiley, 2nd ed. 2009.

ELECTRODYNAMICS-II

Pre-requisites: **Electrodynamics-I**

Credit Hours: **3 (3-0)**

Course Code: **PHY 353**

Objective(s)

To understand the basic ideas of electromagnetism and the various phenomenon associated with electric and magnetic field and their propagations.

Learning Outcomes: After studying this subject, the student will learn the basic ideas of electromagnetism and the various phenomenon associated with electric and magnetic field and their propagations

This course is the second part of the core level undergraduate course on Electromagnetic Theory and a previous knowledge of Electromagnetic Theory I is expected.

Week1: Electrodynamics, Electromotive force: Ohm's law, electromotive force and motional emf, electromagnetic induction: Faraday's law, the induced electric field, inductance,

Week 2: Energy in magnetic fields, Maxwell's equations: electrodynamics before Maxwell, how Maxwell fixed Ampere's law,

Week 3: Maxwell's equations, magnetic charges, Maxwell's equations in matter, boundary conditions.

Week 4: Conservation Laws, Charge and energy: the continuity equation, Poynting's theorem, momentum: Newton's third law in electrodynamics,

Week 5: Maxwell's stress tensor, conservation of momentum, angular momentum.

Week 6: Electromagnetic Waves, Waves in one dimension: the wave equation, sinusoidal waves, boundary conditions, reflection and transmission, polarization,

Week 7: electromagnetic waves in vacuum: the wave equation for E and B, monochromatic plane waves, energy and momentum in electromagnetic waves, electromagnetic waves in matter: propagation in linear media, reflection and transmission at normal incidence,
Week 8: Reflection and transmission at oblique incidence, absorption and dispersion: electromagnetic waves in conductors, reflection at a conducting surface,
Week9: The frequency dependence of permittivity, guided waves: wave guides, The waves in a rectangular wave guide, the coaxial transmission line.
Week 10: Potentials and Fields, The potential formulation: scalar and vector potentials, gauge transformations, Coulomb gauge and Lorentz gauge,
Week 11: Continuous distributions: retarded potentials, Jefimenko's equations, point charges: Lienard-Wiechert potentials, the field of a moving point charge.
Week 12: Radiation, Dipole Radiation, what is radiation, electric dipole radiation, magnetic dipole radiation, radiation from an arbitrary source, point charges:
Week 13: Power radiated by a point charge, radiation reaction, the physical basis of the radiation reaction. Electrodynamics and Relativity, The special theory of relativity.
Week 14: Einstein's postulates, the geometry of relativity, the Lorentz transformations, the structure of space-time, relativistic mechanics: proper time and proper velocity,
Week 15: Relativistic energy and momentum, relativistic kinematics, relativistic dynamics, relativistic electrodynamics: magnetism as a relativistic phenomenon,
Week 16: How the field transform, the field tensor, electrodynamics in tensor notation, relativistic potentials.

Recommended Books

1. D. J. Griffiths, "Introduction to Electrodynamics", ed. Prentice Hall, 3rd ed. 1999.
2. M. N. O. Sadiku, "Elements of Electromagnetics", Oxford University Press, 5th ed. ed. 2009.
3. F. Melia, "Electrodynamics", University of Chicago Press, 1st ed. 2001.
4. Hearld J and W. Muller-Kristen, "Electrodynamics", World Scientific Publishing, 2nd ed. 2011.

ELECTRONICS-II

Pre-requisites: **Electronics-I**
Credit Hours: **3 (3-0)**
Course Code: **PHY 354**
Objective(s)
The main objective of this course is to inculcate in students the ability to analyze and design basic analog electronic circuits that will be used as building blocks in the design of larger systems.

Learning Outcomes: After studying this subject, the student will learn to analyze and design basic analog electronic circuits that will be used as building blocks in the design of larger systems.

Week 1: Amplifiers and their Frequency Response, Cascade amplifier, The Amplifier pass band, the frequency plot, Low frequency plot, Low frequency limit.
Week 2: The un-bypassed emitter resistor, high frequency equivalent circuit, The Miller Effect, high frequency limit of transistor, bandwidth of a cascade amplifier.
Week 3: Feedback, Positive and Negative feedback, Principle of feedback amplifier, stabilization of gain by negative feedback, Bandwidth improvement with negative feedback,
Week 4: Reduction of nonlinear distortion, control of amplifier output and input resistance, current series feedback circuit, voltage shunt feedback circuit.
Week 5: Oscillators, Introduction, Classification of oscillators, Damped and undamped oscillators, the oscillatory circuit, frequency stability of an oscillator,
Week 6: Essentials of a feedback LC oscillator, tuned base oscillator, Hartley oscillator, Colpitis oscillator, crystal oscillator.
Week 7: Power Amplifiers, Introduction, Power relation in class-A amplifiers, effect of thermal environment, determination of the output distortion, class-B amplifier, efficiency of class-A and class-B amplifiers.
Week 8: Modulation and Demodulation, Introduction, carrier wave modulation, Need for modulation, radio Broadcasting, Methods of modulation, amplitude modulation,
Week 9: Forms of amplitude modulation, single side band system of modulation, Diode for linear detector for amplitude modulation, High power level amplitude modulation, automatic volume control, Frequency modulation.
Week 10: Multivibrators, Multivibrators, Basic types of Multivibrators, uses of Multivibrators, Actable Multivibrators, Mono-stable Multivibrators, Bi-stable Multivibrators, Schmitt Trigger Circuit.
Week 11: Integrated Circuits, Introduction, Integrated circuit advantages and drawbacks, scale of integration, classification of integrated circuit by structure,
Week 12: Classification of integrated circuit by function, comparison between different integrated circuit. Integrated circuit terminology, Integrated circuit fabrication,
Week 13: Basic processing steps. Silicon device processes Silicon wafer preparation, diffusion, Oxidation photolithography, Chemical vapor deposition,
Week 14: Metallization, Circuit probing, Scribing and separating into chips, Mounting and packing applications of integrated circuits.
Week 15: Digital Circuits, Decimal, Binary, Octal, hexadecimal number systems, conversion of decimal numbers to any other number system and vice-versa,
Week 16: Binary codes, OR, AND, NOT, NAND, NOR logic gates, Boolean algebra. Boolean expressions, simplification of Boolean expression using Boolean Algebra.

Recommended Books:

1. Thomas L. Floyd, "Electronics Fundamentals: Circuits, Devices and Applications", Prentice Hall, 8th ed. 2009.
2. B. Grob, "Basic Electronics", McGraw-Hill, Tch ed. 1997.
3. B. Streetman and S. Banerjee "Solid State Electronics Devices", Prentice Hall, 6th ed. 2005.
4. A. Bar-lev, "Semiconductor and Electronics Devices", Prentice Hall, 3rd ed. 1993.
5. D. H. Navon and B. Hilbert, "Semiconductor Micro-devices and Materials", CBS College Publishing, 1986.
6. A. P. Malvino, "Electronic Principles", McGraw-Hill, 7th ed. 2006.
7. R. T. Paynter, "Introductory Electric Circuits", Prentice Hall, 1998.

STATISTICAL MECHANICS

Pre-requisites: **Heat and Thermodynamics, Calculus-II, Statistics-I**
Credit Hours: **3 (3-0)**
Course Code: **PHY 355**

Objective(s)

The objective of this course is to approach the thermodynamics properties of a system from the statistical point of view. Students will be taught to address problems of systems consisting of large number of particles by studying their collective behavior.

Learning Outcomes: After studying this subject, the student will learn the thermodynamics properties of a system from the statistical point of view. Students will be able to address problems of systems consisting of large number of particles by studying their collective Behaviour

Week 1: Review of Classical Thermodynamics, States, macroscopic vs. microscopic, "heat" and "work", energy,

Week 2: Entropy, equilibrium, laws of thermodynamics, Equations of state,

Week 3: Thermodynamic potentials, temperature, pressure, chemical potential, thermodynamic processes (engines, refrigerators), Maxwell relations, phase equilibria.

Week 4: Foundation of Statistical Mechanics, Phase Space, Trajectories in Phase Space, Conserved Quantities and Accessible Phase Space,

Week 5: Macroscopic Measurements and Time Averages, Ensembles and Averages over Phase Space, Liouville's Theorem, The Ergodic Hypothesis, Equal a priori Probabilities. Specification of the state of a system,

Week 6: Concept of ensembles, elementary probability calculations, distribution functions, statistical interpretation of entropy (Boltzmann theorem).

Week 7: Statistical Ensembles, Micro canonical ensemble, canonical ensemble and examples (e.g., paramagnet)

Week 8: Calculation of mean values, calculation of partition function and its relation with thermodynamic quantities,
Week 9: The grand canonical ensemble and examples (e.g. adsorption), calculation of partition function and thermodynamic quantities.
Week 10: Simple Applications of Ensemble Theory, Monoatomic ideal gas in classical and quantum limit,
Week 11: Gibb's paradox and quantum mechanical enumeration of states, equipartition theorem and examples (ideal gas, harmonic oscillator),
Week 12: Specific heat of solids, quantum mechanical calculation of para-magnetism.
Week 13: Quantum Statistics, In-distinguishability and symmetry requirements, Maxwell-Boltzmann statistics, Bose-Einstein and photon statistics,
Week 14: Fermi Dirac statistics (distribution functions, partition functions). Examples: polyatomic ideal gas (MB), black body radiation (photon statistics),
Week 15: Conduction electrons in metals (FD), Bose condensation (BE). Systems of Interacting Particles: Lattice vibrations in solids,
Week 16: Van der Waals gas, mean field calculation, ferromagnets in mean field approximation.

Recommended Books:

1. F. Reif, "Fundamentals of Statistical and Thermal Physics", Waveland Pr Inc, 2008.
2. W. Brewer, F. Schwabl, "Statistical Mechanics", Springer, 2nd ed. 2006.
3. T. L. Hill, "Statistical Mechanics", World Scientific Publishing Company, (2004).
4. K. Huang, "Statistical Mechanics", John Wiley, 2nd ed. 1987.

QUANTUM MECHANICS-II

Pre-requisites: **Quantum Mechanics-I**
Credit Hours: **3 (3-0)**
Course Code: **PHY 401**

Objective(s)

The objective of this course is to study quantum systems using advanced mathematical techniques, in particular the students will learn how to do quantum mechanics rather than what quantum mechanics means.

Learning Outcomes: After studying this subject, the student will learn to apply advanced quantum mechanical techniques is solving various problems in advanced physics courses.

Week 1: Addition of Angular Momenta, Total angular momentum in classical mechanics, total angular momentum in quantum mechanics,
Week 2: Addition of two spin ½ angular momenta, addition of two arbitrary angular momenta, Clebsch-Gordon coefficients, addition of spherical harmonics,

Week 3: Vector operators, Wigner-Eckart theorem, electric Multi-pole moments, Evolution of two angular momenta J1 and J2 coupled by an interaction a J1 . J2.
Week 4: Stationary Perturbation Theory, Description of the method, perturbation of a non-degenerate level, perturbation of a degenerate level,
Week 5: One-dimensional harmonic oscillator subjected to a perturbing potential, interaction between the magnetic dipoles of two spin ½ particles, Van der waals forces,
Week 6: Volume effect and the influence of the spatial extension of the nucleus on the atomic levels, variational method, energy bands of electrons in solids,
Week 7: A simple example of the chemical bond: The ion Applications of Perturbation Theory to Atomic Systems: fine and hyperfine structure of atomic levels in hydrogen,
Week 8: Calculation of the mean values of the spin-orbit coupling in the 1s, 2s and 2p levels, hyperfine structure And the Zeeman effect for muonium and positronium, Stark effect.
Week 9: Approximation Methods for Time-Dependent Problems, Statement of the problem, approximate solution of the Schrodinger equation,
Week 10: An important special case, Sinusoidal or constant perturbation, Interaction of an atom with electromagnetic waves, linear and non-linear response of a two-level system subjected to a sinusoidal perturbation,
Week 11: Oscillations of a system between two discrete states under the effect of a resonant perturbation, Rabi flopping, decay of discrete state resonantly coupled to a continuum of final states, Fermi's golden rule.
Week 12: Systems of Identical Particles, Identical particles, Permutation operators, the summarization postulate, difference between bosons and fermions,
Week 13: Pauli's exclusion principle, many-electrons atom and their electronic configurations, energy levels of the helium atom,
Week 14: Configurations terms, multiplets, spin isomers of hydrogen (ortho and para hydrogen).
Week 15: Scattering by a Potential, Importance of collision phenomena, Stationary scattering states, scattering cross section, scattering by a central potential.
Week 16: Method of partial waves, phenomenological description of collisions with absorption.

Recommended Books:

1. D.J. Griffiths, "Introduction to Quantum Mechanics", Addison-Wesley, 2nd ed. 2004.
2. R. Liboff, "Introductory Quantum Mechanics", Addison-Wesley, 4th ed. 2002.
3. N. Zettili, "Quantum Mechanics: Concepts and Applications", John Wiley, 2nd ed. 2009.

ATOMIC AND MOLECULAR PHYSICS

Pre-requisites:	**Quantum Mechanics-I**
Co-requisite:	**Quantum Mechanics-II**
Credit Hours:	**3 (3-0)**

Course Code: **PHY 402**

Objective(s):
To provide an introduction to the structure and spectra of atoms and molecules. To prepare students for more advanced courses on Physics of Atoms, Molecules and Photons.
Learning Outcomes: After studying this subject, the student will learn the structure and spectra of atoms and molecules. The students will be able to apply techniques to more advanced courses on Physics of Atoms, Molecules and Photons.

Week 1: One Electron Atoms, Review of Bohr Model of Hydrogen Atom,
Week 2: Reduced Mass, Atomic Units and Wavenumbers, Energy Levels and Spectra, Schrodinger Equation for One-Electron Atoms,
Week 3: Quantum Angular Momentum and Spherical Harmonics, Electron Spin, Spin-Orbit interaction. Levels and Spectroscopic Notation, Lamb Shift,
Week 4: Hyperfine Structure and Isotopic Shifts. Rydberg Atoms.
Week 5: Interaction of One-Electron Atoms with Electromagnetic Radiation, Radiative Transition Rates, Dipole Approximation, Einstein Coefficients, Selection Rules,
Week 6: Dipole Allowed and Forbidden Transitions. Metastable Levels, Line Intensities and Lifetimes of Excited States,
Week 7: Shape and Width of Spectral Lines, Scattering of Radiation by Atomic Systems, Zeeman Effect, Linear and Quadratic Stark Effect.
Week 8: Many-Electron Atoms, Schrodinger Equation for Two-Electron Atoms, Para and Ortho States, Pauli's Principle and Periodic Table,
Week 9: Coupling of Angular Momenta, L-S and J-J Coupling. Ground State and Excited States of Multi Electron Atoms, Configurations and Terms.
Week 10: Molecular Structure and Spectra, Structure of Molecules, Covalent and Ionic Bonds, Electronic Structure of Diatomic Molecules,
Week 11: Rotation and Vibration of Diatomic Molecules, Born-Oppenheimer Approximation.
Week 12: Electronic Spectra, Transition Probabilities and Selection Rules,
Week 13: Frank Condon Principle, H2+ and H2. Effects of Symmetry and Exchange. Bonding and Anti-bonding Orbitals.
Week 14: Electronic Spin and Hund's Cases, Nuclear Motion:
Week 15: Rotation and Vibrational Spectra (Rigid Rotation, Harmonic Vibrations). Selection Rules.
Week 16: Spectra of Triatomic and Polyatomic molecules, Raman Spectroscopy.
Recommended Books:
1. C. J. Foot, "Atomic Physics", Oxford University Press, 2005.
2. B. H. Bransden and C. J. Joachain, "Physics of Atoms and Molecules", Pearson Education, 2nd ed. 2008.
3. W. Demtroder, "Atoms, Molecules and Photons", y, Springer, 2nd ed. 2010.
4. C. N. Banwell and E. M. McCash, "Fundamentals of Molecular Spectroscopy", McGraw-Hill,

4th ed. 1994.
5. J. M. Hollas, “Basic Atomic & Molecular Spectroscopy”, John Wiley, 2002.

SOLID STATE PHYSICS-I

Pre-requisites: **Quantum Mechanics I, Statistical Mechanics**
Credit Hours: **3 (3-0)**
Course Code: **PHY 403**
Objective(s):
The objective of this course is to provide students the basic physical concepts and mathematical tools which are used to describe solid.
Learning Outcomes: After studying this subject, the student will learn the basic physical concepts and mathematical tools which are used to describe solid.

Week 1: Crystal Structure Lattices and basis, Symmetry operations,
Week 2: Fundamental Types of Lattice, Position and Orientation of Planes in Crystals, Simple crystal structures.
Week 3: Crystal Diffraction and Reciprocal Lattice, Diffraction of X-rays, Neutrons and electrons from crystals; Bragg’s law;
Week 4: Reciprocal lattice, Ewald construction and Brillouin zone, Fourier Analysis of the Basis.
Week 5: Phonons and Lattice, Quantization of Lattice Vibrations,
Week 6: Phonon momentum, inelastic scattering by phonons,
Week 7: Lattice Vibrations for Monoatomic and diatomic basis, Optical Properties in the Infrared region.
Week 8: Thermal Properties of Solids, Lattice heat Capacity, Classical model,
Week 9: Einstein Model, Enumeration of normal modes, Density of state in one, two or three dimensions, Debye model of heat capacity,
Week 10: Comparison with experimental results, thermal conductivity and resistivity, Umklapp processes.
Week 11: Electrical Properties of Metals, Classical free electron theory of metals,
Week 12: Energy levels and density of orbital’s in one dimension,
Week 13: Effect of temperature on the Fermi–Dirac distribution function, properties of the free electron gas,
Week 14: Electrical conductivity and Ohm’s Law, thermal and electrical conductivities of metals and their ratio,
Week 15: Motion of free electrons in magnetic fields, cyclotron frequency,
Week 16: Static magneto conductivity and Hall Effect along with applications.

Recommended Books:

1. C. Kittle, "Introduction to Solid State Physics", John Wiley, 8th ed. 2005.
2. N. W. Ashcroft and N. D. Mermin, "Solid State Physics", Rinehart & Winston, 1976.
3. S. R. Elliott, "The Physics and Chemistry of Solids", John Wiley, 1998
4. M. A. Omar, "Elementary and Solid State Physics", Pearson Education, 2000.
5. H. M. Rosenberg, "The Solid State", Oxford Science Publication, 3rd ed. 1988.
6. M. A. Wahab, "Solid State Physics", Narosa Publishing House, 1999.

SOLID STATE PHYSICS -II

Pre-requisites: **Solid State Physics-I**
Credit Hours: **3 (3-0)**
Course Code: **PHY 451**
Objective(s):
The objective of this course is to understand the transport properties in solids, Dielectric and magnetic properties of materials and superconductivity.
Learning Outcomes: After studying this subject, the student will learn the transport properties in solids, Dielectric and magnetic properties of materials and superconductivity.

Week 1: Dielectric Properties of Solids, Polarization, Depolarization, Local and Maxwell field, Lorentz field, Clausius-Mossotti relation
Week 2: Dielectric Constant and Polarizability, Measurement of dielectric constant, ferro electricity and ferroelectric crystals, Phase Transitions,
Week 3: First and 2nd order phase transitions, Applications
Week 4: Semiconductors: General properties of semiconductors, intrinsic and extrinsic semiconductors, their band structure,
Week 5: Carrier statistics in thermal equilibrium, band level treatment of conduction in semiconductors and junction diodes, diffusion and drift currents,
Week 6: Collisions and recombination times.
Week 7: Optical Properties, Interaction of light with solids, Optical Properties of Metals and Non-Metals, Kramers Kronnig Relation, Excitons,
Week 8: Raman Effect in crystals, optical spectroscopy of solids.
Week 9: Magnetic Properties of Materials**:** Magnetic dipole moment and susceptibility, different kinds of magnetic materials,
Week 10: Langevin diamagnetic equation, Paramagnetic equation and Curie law, Classical and quantum approaches to paramagnetic materials.
Week 11: Ferro-magnetic and anti – ferromagnetic order, Curie point and exchange integral,
Week 12: Effect of temperature on different kinds of magnetic materials and applications.
Week 13: Superconductivity, Introduction to superconductivity,

Week 14: Zero-Resistance and Meissner Effect , Type I and Type II superconductors, Thermodynamic fields,
Week 15: Tow fluid model, London equations , BCS and Ginzburg Landau Theory,
Week 16: Vortex behavior, Critical Current Density, Josephson effect and applications.

Recommended Books:

1. C. Kittle, "Introduction to Solid State Physics", John Wiley, 8th ed. 2005.
2. N. W. Ashcroft and N. D. Mermin, "Solid State Physics", Rinehart & Winston, 1976.
3. G. Burns, "High Temperature Superconductivity: An Introduction", Academic Press, 1992.
4. M. Fox, "Optical Properties of Solids", Oxford University Press, 2nd ed. 2010.
5. N. A. Spaldin, "Magnetic Materials: Fundamentals and Device Applications", Cambridge University Press, 2nd ed. 2010.

NUCLEAR PHYSICS

Pre-Requisites:	**Modern Physics**
Credit Hours:	**3 (3-0)**
Course Code:	**PHY 404**

Objective(s):
To understand the nuclear structure using different nuclear models. To understand the nature of nuclear forces. To give understanding of radioactivity and nuclear reactions.
Learning Outcomes: After studying this subject, the student will learn the nuclear structure using different nuclear models. The students will be able to understand the nature of nuclear forces radioactivity and nuclear reactions.

Week 1: Introduction to Nuclear Physics Starting from Becquerel's discovery of radioactivity to Chadwick's neutron.
Week 2: Basic Properties of Nucleus
Week 3: Nuclear size, mass, binding energy, nuclear spin,
Week 4: Magnetic dipole and electric quadrupole moment, parity and statistics.
Week 5: Nuclear Forces Yukawa's theory of nuclear forces.
Week 6: Nucleon scattering, charge independence and spin dependence of nuclear force, isotopic spin.
Week 7: Nuclear Models Liquid drop model, Fermi gas model, Shell model,
Week 8: Collective model Theories of Radioactive Decay: Theory of Alpha decay and explanation of observed phenomena,
Week 9: Measurement of Beta ray energies, the magnetic lens spectrometer,
Week 10: Fermi theory of Beta decay, Neutrino hypothesis, theory of Gamma decay,

Week 11: Multipolarity of Gamma rays, nuclear isomerism, Nuclear Reactions Conservation laws of nuclear reactions,
Week 12: Q-value and threshold energy of nuclear reaction, energy level and level width
Week 13: Cross sections for nuclear reactions,
Week 14: compound nucleolus theory of nuclear reaction and its limitations,
Week 15: Direct reaction, resonance reactions,
Week 16: Breit-Wigner one level formula including the effect of angular momentum.

Recommended Books:

1. E. Segre, “Nuclei and Particles”, Bejamin-Cummings, 2nd ed. 1977.
2. Kaplan, “Nuclear Physics”, Addison-Wisely, 1980.
3. Green, “Nuclear Physics”, McGraw-Hill, 1995.
4. K. S. Krane, “Introducing Nuclear Physics”, John Wiley, 3rd ed. 1988.
5. B. Povh, K. Rith, C. Scholtz, F. Zetsche, “Particle and Nuclei”, 1999.

Annexure “C”

DETAIL OF ELECTIVE COURSES FOR BS (4 YEAR) PROGRAM

The elective courses can be chosen from the list according to the availability of expert teachers.

List of Elective courses for BS Physics Programme

	Subjects	Cr. Hr	C. Code	PR/CR (BS-Physics)	PR/CR (M.Sc. Physics)
1.	Plasma Physics	3(3-0)	PHY-411	PHY-201, PHY-353	PHY-353
2.	Electronic Materials and Devices	3(3-0)	PHY-461	PHY-251, PHY-304	PHY-304
3.	Materials Science	3(3-0)	PHY-462	PHY-403	PHY-403
4.	Nano Science and Nanotechnologies	3(3-0)	PHY-463	PHY-451, PHY-401	PHY-451, PHY-401
5.	Digital Electronics	3(3-0)	PHY-464	PHY-354	PHY-354
6.	Methods of Experimental Physics	3(3-0)	PHY-465	----	----
7.	Environmental Physics	3(3-0)	PHY-466	----	----
8.	Introduction to Quantum Computing	3(3-0)	PHY-467	PHY-352, PHY-477	PHY-352, PHY-477
9.	Quantum Information Theory	3(3-0)	PHY-468	PHY-352	PHY-352
10.	Quantum Field Theory	3(3-0)	PHY-469	PHY-401	PHY-401
11.	Lasers	3(3-0)	PHY-470	PHY-401, PHY-402	PHY-401, PHY-402

12.	Experimental Techniques in Particle and Nuclear Physics	3(3-0)	PHY-471	PHY-474, PHY-404	PHY-474, PHY-404
13.	Fluid Dynamics	3(3-0)	PHY-472	PHY-101, Calculus-I, ODEs	
14.	Introduction to Photonics	3(3-0)	PHY-473	PHY-201, PHY-251, Linear algebra, PHY-304	PHY-304
15.	Particle Physics	3(3-0)	PHY-474	PHY-401, PHY-404	PHY-401, PHY-404
16.	Computer Simulations in Physics	3(3-0)	PHY-475	Calculus-II, Linear algebra, Statistics-I, ODEs, PHY-101, Into. to Computing	----
17.	Surface Sciences	3(3-0)	PHY-476	PHY-451	PHY-451
18.	Computational Physics	3(3-0)	PHY-477	----	----
19.	Clay Science	3(3-0)	PHY-478	PHY-403	PHY-403

PLASMA PHYSICS

Pre-requisite: **Electromagnetic Theory-II, Waves and Oscillations**
Credit Hours: **3 (3-0)**
Course Code: **PHY-411**

Objective(s):
To learn about the importance of the plasma along with the basic concept of plasma. To know fluid description of the plasma.
Learning Outcomes:
After studying this course the students will learn the importance of the plasma along with the basic concept of plasma. And to know fluid description of the plasma.

Week 1: Introduction to Basic Concepts
Week 2: Occurrence of plasma
Week 3: Concept of temperature, Debye shielding
Week 4: The plasma parameter, Criteria for plasma.

Week 5: Applications of Plasma Physics
Week 6: Single-particle motion in electromagnetic field
Week 7: Uniform and non-uniform E and B fields
Week 8: Time-variant E and B fields
Week 9: Fluid description of plasma
Week 10: Wave propagation in plasma
Week 11: Derivation of dispersion relations for simple electrostatic and electromagnetic modes
Week 12: Introduction to Controlled Fusion
Week 13: Basic nuclear fusion reactions
Week 14: Reaction rates and power density
Week 15: Radiation losses from plasma
Week 16: Operational conditions

Recommended Books:

1. F. F. Chen, "Introduction to Plasma Physics", 2nd ed. Plenum, 1995.
2. D. A. Gurnett and A. Bhattacharjee, "Introduction to Plasma Physics: with space and laboratory application", Cambridge University Press, 2005.
3. T. J. M. Boyd and J. J. Sanderson, "The Physics of Plasmas", Cambridge University Press, 2003.

ELECTRONIC MATERIALS AND DEVICES

Pre-requisite:	**Electronics-I, Optics**
Credit Hours:	**3 (3-0)**
Course Code:	**PHY-461**

Objective(s):
To understand the relation between electrical, optical and magnetic devices.
Learning Outcomes:
After studying this course the students will learn to understand the relation between electrical, optical and magnetic devices.

Week 1: Semiconductor Fundamentals, Composition, purity and structure of semiconductors, energy band model
Week 2: Band gap and materials classification, charge, effective mass and carrier numbers, density of states
Week 3: The Fermi function and equilibrium distribution of carriers, doping, n and p-type semiconductors and calculations involving carrier concentrations, EF etc.,

Week 4: Temperature dependence of carrier concentrations, drift current, mobility, resistivity and band bending

Week 5: Diffusion and total currents, diffusion coefficients, recombination-generation, minority carrier lie times and continuity equations with problem solving examples.

Week 6: Device Fabrication Processes: Oxidation, diffusion, ion implantation, lithography

Week 7: Thin-film deposition techniques like evaporation, sputtering, chemical vapour deposition (CVD), epitaxy etc.

Week 8: PN Junction and Bipolar Junction Transistor: Junction terminology, Poisson's equation,

Week 9: Qualitative solution, the depletion approximation, quantitative electrostatic relationships, Ideal diode equation, non-idealities

Week 10: BJT fundamentals, Junction field effect transistor, MOS fundamentals.

Week 11: Dielectric Materials: Polarization mechanisms, dielectric constant and dielectric loss, capacitor dielectric materials

Week 12: piezoelectricity, Ferro electricity and pyro electricity.

Week 13: Optoelectronic Devices: Photoconductors, photovoltaics and photodetectors, photodiodes and photovoltaics

Week 14: solar cell basics, LEDs, Lasers, displays, LCDs.

Week 15: Magnetism and Magnetic Materials: Basics of magnetism, hysteresis loops, magnetic domains and anisotropy

Week 16: Hard and soft magnetic materials, transformers, DC motors and data storage.

Recommended Books:

1. R. F. Pierret, "Semiconductor Device Fundamentals", Addison Wesley, 2nd ed. 1996.
2. N. Braithwaite, and G. Weaver, "Electronic Materials", MA: Butterworth, 2nd ed. 1990.
3. S. O. Kasap, "Electronic Materials and Devices", McGraw-Hill, 3rd ed. 2005.
4. R. C. O'Handley, "Modern Magnetic Materials: Principles and Applications", Wiley Inter-Science, 1999.
5. D. Jiles, "Introduction to Magnetism and Magnetic Materials", Chapman & Hall, 2nd ed. 1998.

INTRODUCTION TO MATERIALS SCIENCE

Pre-requisites:	**Solid State Physics-I**
Credit Hours:	**3 (3-0)**
Course Code:	**PHY-462**

Objective(s):

To understand the important aspects of materials. Moving towards microstructures.

Learning Outcomes:

After studying this course the students will learn to understand the important aspects of materials. Moving towards microstructures.

Week 1: Imperfections in Solids: Vacancies, impurities, dislocations
Week 2: Interfacial defects, bulk or volume defects, atomic vibrations
Week 3: Microstructure: Microstructure and microscopy, pressure vs. temperature phase diagrams, temperature vs. composition phase diagrams
Week 4: Equilibrium, thermodynamic functions, variation of Gibbs energy with temperature and composition, general features of equilibrium phase diagrams
Week 5: Solidification, diffusion mechanisms, nucleation of a new phase, phase diagrams of Fe-C system and other important alloys, materials fabrication
Week 6: Mechanical Behavior of Materials: Normal stress and normal strain, shear stress and shear strain, elastic deformation, plastic deformation, Young's modulus, shear modulus
Week 7: Poisson's ratio, elastic strain energy, thermal expansion, estimate of the yield stress, dislocations and motion of dislocations
Week 8: Slip systems, dislocations and strengthening mechanisms
Week 9: Fracture mechanics, ductile fracture, brittle fracture, Griffith criterion, ductile fracture,
Week 10: Toughness of engineering materials, the ductile-brittle transition temperature, cyclic stresses and fatigue, creep.
Week 11: Polymers: Polymer basics, polymer identification, polymer molecules, additional polymerization
Week 12: step growth polymerization, measurement of molecular weight, thermosetting polymers and gels, rubbers and rubber elasticity
Week 13: Configuration and conformation of polymers, the glassy state and glass transition, determination of Tg
Week 14: Effect of temperature and time, mechanical properties of polymers, case studies in polymer selection and processing
Week 15: Biomaterials: Introduction to biomaterials, materials selection, biopolymers
Week 16: Structural polysaccharide hard materials biomaterials.

Recommended Books:

1. W. D. Callister, "Materials Science and Engineering: An Introduction", Wiley, 7th ed. 2006.
2. W. D. Callister and D. G. Rethwisch "Fundamentals of Materials Science and Engineering: An Integrated Approach", Wiley, 4th ed. 2012.
3. J. F. Shackelford, "Introduction to Materials Science for Engineers", Prentice Hall, 7th ed. 2008.
4. http://www.msm.cam.ac.uk/teaching/index.php,
5. http://www.doitpoms.ac.uk/

INTRODUCTION TO NANO SCIENCE AND NANOTECHNOLOGIES

Pre-requisite: **Solid State Physics-II, Quantum Mechanics-II**
Credit Hours: **3 (3-0)**

Course Code: **PHY-463**

Objective(s):

Introduce the concept and applications of nano sciences and nanotechnologies. Nano structures and nano technologies.

Learning Outcomes:

After studying this course the students will learn the concept and applications of nano sciences nanotechnologies and Nano structures.

Week 1: Introduction: Feynman talks on small structures, Nano scale dimension, Course goals and objectives.

Week 2: Quantum Effects: Wave particle duality, Energy quanta, Uncertainty principle, De Broglie relation, Quantum Dots, Moore's law, tunneling.

Week 3: Surfaces and Interfaces: Interfaces, Surface chemistry and physics, Surface modification and characterization

Week 4: Thin Films, Sputtering, Self-assembled films

Week 5: Material Properties: Subatomic physics to chemical systems, types of chemical bonds, solid state Physics, materials and properties.

Week 6: Tools and Instrumentation: STM, AFM, Electron Microscopy, Fluorescence methods, synchrotron radiation.

Week 7: Fabricating Nano Structures: Lithography (photo and electron beam), MBE, Self-assembled masked, FIB, Stamp technology, Nano junctions.

Week 8: Electrons in Nano Structures: Variation in electronic properties, free electron model

Week 9: Bloch's theorem, Band structure, Single electron transistor, Resonant tunneling.

Week 10: Molecular Electronics: Lewis structures, Approach to calculate Molecular orbitals, Donor Acceptor properties

Week 11: Electron transfer between molecules, Charge transport in weakly interacting molecular solids, Single molecule electronics.

Week 12: Nano Materials: Quantum dots, nano wires, nano photonics

Week 13: Magnetic nano structures, nano thermal devices, Nano fluidic devices, biomimetic materials.

Week 14: Nano Biotechnology: DNA micro-arrays, Protein and DNA Assembly

Week 15: Digital cells, genetic circuits, DNA computing.

Week 16: Nanotechnology the Road Ahead: Nanostructure innovation, Quantum Informatics, Energy solutions.

Recommended Books:

1. S. Lindsay, “Introduction to Nanoscience”, Oxford University Press, 2009.
2. C. Binns, “Introduction to Nanoscience and Nanotechnology (Wiley Survival Guides in Engineering and Science)”, Wiley, 2010.

DIGITAL ELECTRONICS

Pre-requisites: **Electronics-II**
Credit Hours: **3 (3-0)**
Course Code: **PHY-464**

Objective(s):
To learn the basics of digital electronics such as Boolean Algebra. To develop logic circuit using the Boolean Algebra. To understand the computer interface and micro-controller along with the embedded systems.

Learning Outcomes:
After studying this course the students will learn the basics of digital electronics such as Boolean Algebra. And to develop logic circuit using the Boolean Algebra, understanding the computer interface and micro-controller along with the embedded systems.

Week 1: Review of Number Systems: Binary, Octal and Hexadecimal number system, their inter-conversion
Week 2: Concepts of logic, truth table, basic logic gates
Week 3: Boolean algebra: De Morgan's theorem, simplification of Boolean expression by Boolean Postulates and theorem, K-maps and their uses. Don't care condition
Week 4: Different codes. (BCD, ASCII, Gray etc.). Parity in Codes
Week 5: IC Logic Families: Basic characteristics of a logic family. (Fan in/out, Propagation delay time, dissipation, noise margins etc.
Week 6: Different logic based IC families (DTL, RTL, ECL, TTL, CMOS)
Week 7: Combinational Logic Circuit: Logic circuits based on AND – OR, OR-AND, NAND, NOR Logic
Week 8: Gate design, addition, subtraction (2's compliments, half adder, full adder, half subtractor, full subtractor encoder, decoder, PLA. Exclusive OR gate
Week 9: Sequential Logic Circuit: Flip-flops clocked RS-FF, D-FF, T-FF, JK-FF, and Shift Register
Week 10: Counters (Ring, Ripple, up-down, Synchronous) A/D and D/A Converters
Week 11: Memory Devices: ROM, PROM, EAPROM, EE PROM, RAM, (Static and dynamic) Memory mapping techniques
Week 12: Micro Computers: Computers and its types, all generation of computers, basic architecture of computer, micro-processor (ALU, UP Registers, Control and Time Section).
Week 13: Addressing modes, Instruction set and their types, Discussion on 8085/8088, 8086 processor family, Intel Microprocessor Hierarchy
Week 14: Micro-controller/ Embedded System: Introduction to Embedded and microcontroller based systems

Week 15: The Microprocessor and microcontroller applications and environment, microcontroller characteristics, features of a general purpose microcontroller
Week 16: Microchip Inc and PIC microcontroller, Typical Microcontroller examples: Philips 80C51 & 80C552 and Motorola 68Hc05/08, Interfacing with peripherals.

Recommended Books:

1. M. M. Mono, "Digital Logic and Computer Design", Prentice Hall, 1995.
2. R. Tokheim, "Digital Electronics", McGraw Hill, 7th ed. 2007.
3. B. B. Brey, "The Intel Microprocessors: Architecture, Programming and Interfacing", Merril, 2nd ed. 1991.
4. Thomas L. Floyd, "Electronics Fundamentals: Circuits, Devices and Applications", Prentice Hall, 8th ed. 2009.
5. T. Wilmshurst, "The Design of Small-Scale Embedded Systems", Palgrave, 2001.

METHODS OF EXPERIMENTAL PHYSICS
Credit Hours: **3 (3-0)**
Course Code: **PHY-465**

Objective(s):
To learn about the vacuum techniques. To learn the detection techniques about radiation, temperature. To learn about the measuring techniques along with data analysis.
Learning Outcomes:
after studying this course the student will learn about the vacuum techniques. And to learn the detection techniques about radiation, temperature and data analysis.

Week 1: Introduction to synthesis techniques and characterization tools
Week 2: Synthesis and characterization of OD, 1D, 2D and 3D of materials, fabrication of materials
Week 3: Vacuum techniques, Sputtering, Ion Beam, Electron Beam, CVD, XRD, EDX, SEM, TEM, Uv-Vis, FTIR, NMR, XPS, etc.
Week 4: Vacuum Techniques: Gas Transport: Throughout, Pumping Speed, Pump down Time Ultimate pressure. Fore-Vacuum Pumps:
Week 5: Rotary Oil pumps, sorption pumps. Diffusion pumps, sorption pumps (High Vacuum). Production of ultrahigh vacuum
Week 6: Fundamental concepts, guttering pumps, Ion pumps, Cryogenic pumps, Turbo molecular pumps. Measurement of total pressure in Vacuums Systems, Units pressure ranges,
Week 7: Manometers, Perini gauges, The Mc Load gauges, Mass spectrometer for partial measurement of pressure
Week 8: Design of high Vacuum system, Surface to Volume ratio, Pump Choice, pumping system design

Week 9: Vacuum Components, Vacuum valves, vacuum Flanges, Liquid Nitrogen trap, Mechanical feed through & Electrical feed through Leak detection:
Week 10: Basic consideration, leak detection equipment, Special Techniques and problems, Repair Techniques.
Week 11: Radiation Detection and Measurement: GM tubes, scintillation detector, channeltron, photo multipliers, neutron detectors, alpha/beta detectors
Week 12: X-rays/gamma detectors, cosmic rays detectors, Spectrographs and Interferometers
Week 13: Sensor Technology: Sensors for temperature, pressure displacement, rotation, flow, level, speed, rotation position, phase, current voltage, power magnetic field, tilt, metal, explosive and heat.
Week 14: Data Analysis: Evaluation of measurement: Systematic Errors, Accuracy, Accidental Errors, Precision, Statistical Methods, Mean Value and Variance
Week 15: Statistical Control of Measurements, Errors of Direct measurements, Rejection of data, Significance of results, Propagation of errors, preliminary Estimation, Errors of Computation
Week 16: Least squares fit to a polynomial. Nonlinear functions. Data manipulation, smoothing, interpolation and extrapolation, linear and parabolic interpolation.

Recommended Books:

1. F. James, "Statistical Methods in Experimental Physics", World Scientific Company, 2nd ed. 2006.
2. M. H. Hablanian, "High-Vacuum Technology", Marcel Dekker, 2nd ed. 1997.
3. P. Bevington and D. K. Robinson, "Data Reduction and Error Analysis for Physical Science", McGraw-Hill, 3rd ed. 2002.
4. S. Tavernier, "Experimental Techniques in Nuclear and Particle Physics", Springer, 2010.
5. J. B. Topping, "Errors of Observations and Their Treatment", Springer, 4th ed. 1972.
6. Materials characterization techniques, by Zhang S, L. li, and Kumar 2008 CRC press

ENVIRONMENTAL PHYSICS
Credit Hours: **3 (3-0)**
Course Code: **PHY-466**

Objective(s):
To become familiar with the essentials of environment and Global climate. To learn to use spectroscopy for environments.

Learning Outcomes:
after studying this course the students will learn the essentials of environment, Global climate. And spectroscopy for environments.

Week 1: Introduction to the Essentials of Environmental Physics
Week 2: The economic system, living in green house, enjoying the sun, Transport of matter, Energy and momentum, the social and political context.
Week 3: Basic Environmental Spectroscopy, Black body radiation, The emission spectrum of sun, The transition electric dipole moment
Week 4: The Einstein Coefficients, Lambert – Beer's law, The spectroscopy of bi-molecules, Solar UV and life, The ozone filter
Week 5: The Global Climate: The energy Balance, (Zero-dimensional Greenhouse Model), elements of weather and climate, climate variations and modeling.
Week 6: Transport of Pollutants: Diffusion, flow in reverse, ground water. Flow equations of fluid Dynamics
Week 7: Turbulence, Turbulence Diffusion, Gaussian plumes in air, Turbulent jets and planes.
Week 8: Noise: Basic Acoustics, Human Perceptions and noise criteria
Week 9: Reducing the transmission of sound, active control of sound
Week 10: Radiation: General laws of Radiation, Natural radiation
Week 11: Interaction of electromagnetic radiation and plants, utilization of photo synthetically active radiation.
Week 12: Atmosphere and Climate: Structure of the atmosphere, vertical profiles in the lower layers of the atmosphere
Week 13: Lateral movement in the atmosphere, Atmospheric Circulation, cloud and Precipitation, The atmospheric greenhouse effect.
Week 14: Topo Climates and Micro Climates: Effects of surface elements in flat and widely unduling areas, Dynamic action of seliq. Thermal action of selief.
Week 15: Climatology and Measurements of Climate Factor: Data collection and organization, statistical analysis of climatic data, climatic indices, General characteristics of measuring equipment
Week 16: Measurement of temperature, air humidity, surface wind velocity, Radiation balance, precipitation, Atmospheric Pressure, automatic weather stations

Recommended Books:
1. E.t Booker and R. Van Grondelle, "Environmental Physics", John Wiley, 3rd ed. 2011.
2. G. Guyot, "Physics of Environment and Climate", John Wiley, 1998.

INTRODUCTION TO QUANTUM COMPUTING

Pre-requisite: Quantum Mechanics-I, Computational Physics
Credit Hours: 3 (3-0)
Course Code: PHY-467

Objective(s):
To be familiar with the quantum computing. To learn about the Quantum circuits, and cryptography.
Learning Outcomes:
After studying this course the students will learn basics for quantum computing, Quantum circuits, and cryptography.

Week 1: Computer technology and historical background
Week 2: Basic principles and postulates of quantum mechanics
Week 3: Quantum states, evolution, quantum measurement
Week 4: Superposition, Quantization from bits to qubits, operator function
Week 5: Density matrix, Schrodinger equation, Schmidt decomposition
Week 6: EPR and Bell's inequality, Quantum Computation: Quantum Circuits
Week 7: Single qubit operation, Controlled operations, Measurement
Week 8: Universal quantum gates, Single qubit and CNOT gates
Week 9: Breaking unbreakable codes, Code making
Week 10: Trapdoor function, One time pad RSA cryptography
Week 11: Code breaking on classical and quantum computers
Week 12: Schor's algorithm, Quantum Cryptography
Week 13: Uncertainty principle Polarization and Spin basis
Week 14: BB84, BB90, and Ekert protocols
Week 15: Quantum cryptography with and without eavesdropping
Week 16: Experimental realization, Quantum Search Algorithm.

Recommended Books:
1. M. A. Nielson and I. L. Chuang, "Quantum Computation and Quantum Information", Foundation Books, 2007.
2. C. P. Williams and S. H. Clearwater, "Exploration in Quantum Computation" Springer, 2nd ed. 2011. .
3. P. Bouwmester, A. Ekert, and A. Zeilinger, "The Physics of Quantum Information: Quantum Cryptography, Quantum Teleportation, Quantum Computation", Springer, 2010.
4. R. K. Brylinsky and G. Chen, "Mathematics of Quantum Computation" by Chapman & Hall/CRC, 2002.

QUANTUM INFORMATION THEORY

Pre-requisites: **Quantum Mechanics-I**
Credit Hours: **3 (3-0)**
Course Code: **PHY-468**

Objective(s):
To understand the fundamental concepts of quantum information, communication, computation, and physical protocols for quantum computation.

Learning Outcomes:
After studying this course the students will learn to understand the fundamental concepts of quantum information, communication, computation, and physical protocols for quantum computation

Week 1: Review of Quantum Mechanics and overview of Quantum information
Week 2: Postulates of quantum mechanics, quantum states and observables
Week 3: Dirac notation, projective measurements, density operator, pure and mixed states,
Week 4: Entanglement, tensor products, no-cloning theorem, mixed states from pure states in a larger Hilbert space
Week 5: Schmidt decomposition, generalized measurements, (CP maps, POVMs), qualitative overview of Quantum Information
Week 6: Quantum Communication: Dense coding, teleportation, entanglement swapping, instantaneous transfer of information, quantum key distribution
Week 7: Entanglement and its Quantification: Inseparability of EPR pairs, Bell inequality for pure and mixed states
Week 8: Entanglement witnesses, Peres Horodecki criterion, properties of entanglement measures, pure and mixed state entanglement
Week 9: Relative entropy as entanglement measure, entanglement and thermodynamics, measuring entanglement
Week 10: Quantum Information: Classical information theory (data compression, Shannon entropy, von Neumann entropy), fidelity
Week 11: Helstrom's measurement and discrimination, quantum data compression, entropy and information
Week 12: Relative entropy and its statistical interpretation, conditional entropy, Holevo bound, capacity of a quantum channel, relative entropy and thermodynamics, entropy and erasure, Landauer's erasure.
Week 13: Quantum Computation: Classical computation (Turing machines, circuits, complexity theory), quantum algorithms (Deutsch's algorithm, Oracles, Grover's algorithm, factorization and quantum Fourier transform)

Week 14: Role of entanglement in algorithms (search algorithm), modeling quantum measurements, Bekenstein bound
Week 15: Quantum error correction (general conditions, stabilizer codes, 3-qubit codes, relationship with Maxwell's demon), Fault tolerant quantum computation (overview)
Week 16: Physical Protocols for Quantum Information and Computation: Ion trap, optical lattices, NMR, quantum optics, cavity QED.

Recommended Books:

1. V. Vedral, "Introduction to Quantum Information Science", Oxford University Press, 2007.
2. M. Nielsen and I. Chuang, "Quantum Computation and Quantum Information", Cambridge University Press, 10th Anv. ed. 2010.
3. W. Steeb and Y. Hardy, "Problems and Solutions in Quantum Computing and Quantum Information", World Scientific Publishing, 3rd ed. 2011.
4. Book on general quantum mechanics: A. Peres, Quantum Theory: Concepts and Methods, Kluwer Academic Publishers (2002).
5. Seth Lloyd's notes on quantum information available online at: web.mit.edu/2.111/www/notes09/spring.pdf

QUANTUM FIELD THEORY

Pre-requisites: **Quantum Mechanics-II**
Credit Hours: **3 (3-0)**
Course Code: **PHY-469**
Objective(s):
To understand the fundamental concepts of quantum field theory, QED, Quantized Dirac field. Feynman rules for QED, Cross sections and decay rates.
Learning Outcomes:
After studying this course, the students will learn to understand the fundamental concepts of quantum field theory, QED, Quantized Dirac field. Feynman rules for QED, Cross sections and decay rates.

Week 1: Introduction to Lagrangian Field Theory
Week 2: Classical Field Theory
Week 3: Canonical Quantization Noether's theorem
Week 4: Klein-Gordon Field

Week 5: Real Klein-Gordon field. Complex Klein-Gordon field
Week 6: Covariant commutation relations. Meson propagator
Week 7: Dirac Field: Number representation for fermions
Week 8: Quantization of Dirac field
Week 9: Spin-statistics theorem. Fermion propagator
Week 10: Electromagnetic Field: Classical electromagnetic field
Week 11: Covariant quantization. Photon propagator
Week 12: Interacting Fields
Week 13: Interaction Lagrangian and gauge invariance
Week 14: Interaction picture. S-matrix expansion
Week 15: Wick's theorem. Feynman Diagrams
Week 16: Feynman rules for QED. Cross sections and decay rates.

Recommended Books:

1. F. Mandl and G. Shaw, "Quantum Field Theory", Wiley, 2nd ed. 2010.
2. M. E. Peskin and D. V. Schroeder, "An Introduction to Quantum Field Theory", Addison Wesley, 1995.
3. S. Weinberg, "The Quantum Theory of Fields", Vol. 1, Cambridge University Press, 1999.
4. N. N. Bogoliubov and D. V. Shirkov, "Introduction to the Theory of Quantized Fields", John Wiley, 1980.

LASERS

Pre-requisite: **Quantum Mechanics-II, Atomic and Molecular Physics**
Credit Hours: **3 (3-0)**
Course Code: **PHY-470**

Objective(s):
Develop fundamental concepts about lasers. Learn the principles of spectroscopy of molecules and semi-conductors. Understand the optical resonators and laser system. Applications of lasers.
Learning Outcomes:
After studying this course, the student will be able to learn and understand fundamental concepts about lasers, principles of spectroscopy of molecules and semi-conductors, Understand the optical resonators and laser system.

Week 1: Introductory Concepts: Spontaneous Emission, Absorption, Stimulated Emission
Week 2: Pumping Schemes, Absorption and Stimulated Emission Rates, Absorption and Gain Coefficients

Week 3: Resonance Energy Transfers. Properties of Laser Beam: Monochromaticity, Coherence, Directionality, Brightness
Week 4: Spectroscopy of Molecule and Semiconductors: Electronic Energy Levels, Molecular Energy Levels, Level Occupation at Thermal Equilibrium
Week 5: Stimulated Transition, Selection Rules, Radiative and Nonradiative Decay, Semiconductor.
Week 6: Optical Resonators: Plane Parallel (Fabry-Perot) Resonator, Concentric (Spherical) Resonator
Week 7: Confocal, Resonator, Generalized Spherical Resonator
Week 8: Pumping Processes: Optical pumping: Flash lamp and Laser, Threshold Pump Power,
Week 9: Pumping efficiency, Electrical Pumping: Longitudinal Configuration and Transverse Configuration
Week 10: Gas Dynamics Pumping, Chemical Pumping, Rate Equations
Week 11: Threshold Condition and Output Power, Optimum Output Coupling, Laser Tuning
Week 12: Oscillation and Pulsations in Lasers, Q-Switching and Mode-Locking Methods
Week 13: Phase Velocity, Group Velocity, and Group-Delay Dispersion, Line broadening.
Week 14: Lasers Systems, Solid State Lasers: Ruby Laser, Nd: YAG & Nd: Glass Lasers and Semiconductor Lasers
Week 15: Homojunction Lasers Double Heterostructure lasers, Gas lasers: Helium Neon laser, CO_2 laser, Nitrogen Laser and Excimer Lasers, Free-Electron and X-Ray Lasers
Week 16: Laser Applications: Material Processing: Surface Hardening, Cutting, Drilling, Welding etc. Holography, Laser Communication, Medicine, Defense Industry, Atmospheric Physics.

Recommended Books:

1. O. Svelto, "Principles of Lasers", Springer, 5th ed. 2009.
2. J. Eberly and P. Milonni, "Lasers Physics", John Wiley, 2nd ed. 2010.
3. M. O. Scully and M. S. Zubairy, "Quantum Optics", Cambridge University Press, 1997.
4. W. T. Silfvast, "Laser Fundamentals", Cambridge University Press, 2nd ed. 2008.
5. W. M. Steen, J. Mazumder and K. G. Watkins, "Laser Material Processing", Springer, 4th ed. 2010.

EXPERIMENTAL TECHNIQUES IN PARTICLE AND NUCLEAR PHYSICS

Pre-requisites: **Particle Physics, Nuclear Physics**
Credit Hours: **3 (3-0)**
Course Code: **PHY-471**

Objective(s):

To give students with the practical hand on the experimental techniques and to physically understand the nuclear phenomena.

Learning Outcomes:

After studying this course the students will be able to perform practical hand on the experimental techniques and to Physically understand the nuclear phenomena.

Week 1: Review of Basic Concepts: Units used in particle physics, Definition used in particle physics, Types of particles to be detected

Week 2: Cross section, Decay width, Lab Frame and CM frame, Pseudo rapidity

Week 3: History of Accelerator, Linear accelerators, Circular accelerators, Introduction to RHIC, Tevatron, LEP, LHC.

Week 4: Introduction to Accelerators: Lattice and geometry, The arcs, Periodicity, Aperture, Beam crossing angle, Luminosity, RF cavities

Week 5: Power requirements, Longitudinal feedback system, Injection, Injection scheme, PS, SPS, Magnets, Cryogenics, Vacuum system.

Week 6: Introduction to detectors, Need of detectors, Passage of radiation through matter, Cross-section, Interaction probability in a distance x

Week 7: Mean free path, Energy loss of heavy charged particles by atomic collisions, Bohr's, calculation – classical case - The Bethe Bloch formula, Cherenkov radiation

Week 8: Energy loss of electron and photon, Multiple coulomb scattering, Energy straggling, The interaction of photons, The interaction of neutrons.

Week 9: General Characteristics of Detectors and Gas Detectors: Sensitivity, Detector response, Energy resolution The Fano-factor, The response function, Response time

Week 10: Detector efficiency, Dead time- Ionization detectors, Gaseous ionization detectors,

Week 11: Ionization & transport phenomenon in gases, Transport of electrons and ions in gases, Avalanche multiplication

Week 12: The cylindrical proportional counter, The multi-wire proportional counter, The drift chambers, Time projection chambers, Liquid ionization detector. Scintillators, Photomultipliers,

Week 13: Semi-conductor Detectors: Scintillation detectors, Organic scintillation, Inorganic crystals, Gaseous scintillators Glasses, Intrinsic detector efficiency for various radiations, Photomultipliers, Basic construction and operation

Week 14: The photocathode, The electron-optical input system, Semiconductor detectors, Silicon diode detectors, Introduction to CMS and its detectors.

Week 15: Detector Software and Physics Objects: Introduction to Linux operating system, Introduction to CMS software (CMSSW), Basic infrastructure of software

Week 16: Introduction to PYTHIA, Introduction to GEN, SIM, DIGI, RECO, reconstruction of final state objects.

Recommended Books:

1. The Large Hadron Collider Conceptual Design CERN/AC/95-05 (LHC)

2. Detector performance and software, Physics Technical Design Report, Volume1
3. Techniques for Nuclear and Particle Physics Experiments by W.R. Leo
4. R. Fernow, “Introduction to experimental particle physics”, Cambridge University Press, 1989.
5. D. H. Perkins, “Introduction to High Energy Physics”, Cambridge University Press, 4th ed. 2000.

FLUID DYNAMICS
Pre-requisites: **Mechanics, Calculus-I, Differential Equations**
Credit Hours: **3 (3-0)**
Course Code: **PHY-472**
Objective(s):
To know the fundamentals of Fluid Dynamics and its applications in order to physically understand it.
Learning Outcomes:
After studying this course the students will be able to physically understand the fundamentals of Fluid Dynamics and its applications.

Week 1: Phenomenological introduction to fluid dynamics
Week 2: Kinematics and conservation laws
Week 3: Ideal fluids
Week 4: The Euler equations
Week 5: Ir-rotational flow
Week 6: The Navier-Stokes equations
Week 7: Viscous flow: Stokes flow
Week 8: Drag, lubrication theory
Week 9: Thin film flow, Waves
Week 10: surface waves, internal gravity waves
Week 11: nonlinear waves. solitons, shocks
Week 12: Instabilities: linear stability analysis
Week 13: Kelvin-Helmholts instability, Rayleigh Bénard convection
Week 14: Other instabilities
Week 15: Other topics depending on interest and as time permits possibly: airfoil theory, granular flows
Week 16: biophysical flows

Recommended Books:
1. D. J. Acheson, “Elementary Fluid Dynamics”, Oxford University Press, 1990.
2. P. K. Kundu and I.M. Cohen, “Fluid Mechanics”, Academic Press, 4th ed. 2010.
3. D. J. Tritton, “Physical Fluid Dynamics”, Clarendon, 2nd ed. 1988.

4. L. D. Landau and E. M. Lifschitz, “Fluid Mechanics”, Butter worth Heinemann, 2nd ed. 1987.

INTRODUCTION TO PHOTONICS

Pre-requisites: **Waves and Oscillations, Optics, Linear Algebra, Electronics-I**
Credit Hours: **3 (3-0)**
Course Code: **PHY-473**
Objective(s):
To study the application of light and studying the photonic devices including detectors.
Learning Outcomes:
After studying this course the students will be able to know about the application of light and photonic devices including detectors.

Week 1: Guided Wave Optics: Planar slab waveguides, Rectangular channel waveguides
Week 2: Single and multi-mode optical fibers
Week 3: Waveguide modes and field distributions
Week 4: Waveguide dispersion, pulse propagation
Week 5: Gaussian beam Propagation: ABCD matrices for transformation of Gaussian beams,
Week 6: Application to simple resonators
Week 7: Electromagnetic Propagation in Anisotropic Media: Reflection and transmission at anisotropic interfaces
Week 8: Jones Calculus, retardation plates, polarizers
Week 9: Electro-optics and Acousto-optics: Linear electro-optic effect
Week 10: Longitudinal and transverse modulators, amplitude and phase modulation
Week 11: Mach-Zehnder modulators, Coupled mode theory
Week 12: Optical coupling between waveguides, Directional couplers, Photoelastic effect,
Week 13: Acousto-optic interaction and Bragg diffraction, Acousto-optic modulators, deflectors and scanners
Week 14: Optoelectronics: p-n junctions, semiconductor devices
Week 15: laser amplifiers, injection lasers,
Week 16: Photoconductors, Photodiodes

Recommended Books:
1. B. E. A. Saleh and M. C. Teich, “Fundamentals of Photonics”, John Wiley, 2nd ed. 2007.
2. J-M. Liu, “Photonic Devices”, Cambridge University Press, 2009.
3. A. Yariv and P. Yeh, “Photonics: Optical Electronics in Modern Communications”, Oxford University Press, 2006.
4. E. Hecht, “Optics”, Addison-Wesley, 4th ed. 2001.

PARTICLE PHYSICS

Pre-requisites: **Quantum Mechanics-II, Nuclear Physics**
Credit Hours: **3 (3-0)**
Course Code: **PHY-474**
Objective(s):
To know about the elementary particles, their classification and about the interactions among these particles.
Learning Outcomes:
After studying this course the students will have sufficient knowledge about the elementary particles, the ways they are classified and about the interactions among these particles.

Week 1: Introduction to Elementary Particles,
Week 2: Fundamental building blocks and their interactions.
Week 3: Quantum Electrodynamics. Quantum Chromodynamics. Weak interactions. Decays and conservation laws
Week4: Relativistic Kinematics, Lorentz transformations. Four-Vectors.
Week 5: Energy and momentum. Particle collisions. Mandelstam variables.
Week 6: Symmetries, Symmetries and conservation laws,
Week 7: Spin and orbital angular momentum. Flavour symmetries, Parity.
Week 8: Charge conjugation. CP Violation.
Week 9: Time reversal and TCP Theorem.
Week 10: Quantum Electrodynamics, Klein-Gordon equation.
Week 11: Dirac equation. Solution of Dirac equation. Bilinear covariants. Feynman rules for QED.
Week 12: Casmir's trick. Cross sections & lifetimes.
Week 13: Neutrino Oscillations, Solar neutrino problem. Oscillations, Neutrino masses. PMNS mixing matrix.
Week 14: Gauge Field Theories, Lagrangian in Relativistic Field Theory. Gauge Invariance. Yang-Mills Theory.
Week 15: The mass term. Spontaneous symmetry breaking. Higgs mechanism, Higgs boson.
Week 16: Grand Unification. Supersymmetry. Extra dimensions. String theory. Dark energy. Dark Matter.

Recommended Books:
1. D. Griffiths, "Introduction to Elementary Particles", Wiley-VCH, 2nd ed. 2008.
2. F. Halzen and A.D. Martin, "Quarks and Leptons: An introductory course in modern Particle Physics", John Wiley, 1984.
3. D. H. Perkins, "Introduction to High-Energy Physics", Cambridge University Press, 4th ed. 2000.

4. V. D. Barger and R. J. N. Phillips, "Collider Physics", Addison-Wesley, 1996.

COMPUTER SIMULATIONS IN PHYSICS

Pre-requisites: **Calculus-II, Linear Algebra, Probability and Statistics, Differential Equations, Introduction to Computing, Mechanics.**
Credit Hours: **3 (3-0)**
Course Code: **PHY-475**
Objective(s):
The aim is to develop the ability to turn theoretical ideas of mathematics and physics into computer simulations of real-world systems.
Learning Outcomes:
After studying this course the students will learn techniques to understand and develop computer simulations, to solve the differential equations and to understand the simulation in classical physics and Quantum Physics.

Week1: Introduction to computer simulation.
Week2: Programming for Scientific Computation,
Week3: Unix/Linux basics,
Week4: the editingcoding-compiling-debugging-optimizing-visualizing-documenting
Week5: production chain, Fortran95.
Week6: Numerical Programming, Functions, approximation and fitting,
Week7: Numerical calculus.
Week8: Ordinary differential equations, Matrices, Spectral analysis,
Week9: Partial differential equations.
Week10: Modeling and Simulation, Molecular dynamics simulations,
Week11: modeling continuous media Monte Carlo simulations.
Week12: Project, A project will be chosen by the student in consultation with the instructor.
Week13: Selection of the project should be done soon after
Week14: The module on modeling and simulation.
Week15: The final part of the course is reserved for presentation of preliminary and final results.
Week16: Applications of simulations in Physics.

Recommended Books:
1. T. Pang, "An Introduction to Computational Physics", Cambridge University Press, 2008.
2. R. Landau, M. Paez, C. Bordeianu, "A Survey of Computational Physics", Princeton University Press, 2008.

SURFACE SCIENCES

Pre-requisite: **Solid State Physics-II**
Credit Hours: **3 (3-0)**
Course Code: **PHY-476**
Objective(s):
To understand the basics of surface physics and its applications and to learn about the interaction of surface with the ions, electrons etc.
Learning Outcomes:
After studying this course the students will be able to understand the basics of surface physics and its applications. In addition they will have sufficient knowledge about the interaction of surface with the ions, electrons etc.

Week 1: Basics of Surface Science, Surface reactions, Heterogeneous catalysis, Semiconductor technology, Corrosion, Nanotechnology,
Week 2: Surface Structure and Reconstruction: Classification of solids, Crystal structure, Unit cell, Bravais lattices, Electronic Structure of Surfaces: Band structure of metals, insulators and semiconductors, Fermi level, Screening,
Week 3: Work Function, Surface States, Electron Affinity, Ionization Potential, Surface Chirality, Thermodynamics of Surfaces, Equilibrium Crystal Shape.
Week 4: Quantum confinement of Electrons at Surfaces, Interference of Electron Waves, Quantum size effects, Quantum wells, Mechanical Quantum Wells, Quantum Wires, Chemist's Approach, Bonds to Bands.
Week 5: Surface Dynamics, Nucleation and growth of nanostructures and films, Surface Magnetism and magnetic imaging, Diamagnetism,
Week 6: Paramagnetism, Anti-Ferromagnetism, Magnetism in thin films, Kerr microscopy (MOKE), Spin Polarized Photoemission (SP-PEEM), Magnetic Force Microscopy.
Week 7: Surface Study Techniques, Surface Sensitivity and specificity, Explanation and comparison of Low-Energy Electron Diffraction (LEED) and Reflection High-Energy Electron Diffraction (RHEED),
Week 8: Explanation of Near-Edge X-ray Absorption Fine Structure (NEXAFS), High-Resolution Electron Energy Loss Spectroscopy (HREELS),
Week 9: Introduction to Desorption Techniques, Thermal Desorption Spectroscopy (TDS), Electron Stimulated Desorption (ESD),
Week 10: Electron Stimulated Desorption Ion Angular Distribution (ESDIAD), Photon Stimulated Desorption (PSD), Electron Spectroscopy, Theory: Mean free path, Koopman's Theorem, Spin orbit coupling effects, chemical shifts, binding energy,
Week 11: Auger Electron Spectroscopy (AES),X-Ray Photo-electron Spectroscopy, Electron Analyzer, Electron optics, Scanning Tunneling Microscopy (STM), History, Theory, Electronics and applications.

Week 12: Case Studies, Silicon Surfaces: Geometric and Electronic Structure, Molecular Adsorption on Semiconductor Surfaces.
Week 13: Adsorption Properties of CO on Metal Single-Crystal Surfaces, Molecular or dissociative adsorption, Chemical bonding and Orientation, Adsorption Site as a function of coverage, Over layer long-range order.
Week 14: Ammonia Synthesis, Oxide Surfaces. Photovoltaic and Organic Electronics, Different types of semiconductors (organic, inorganic, conjugated polymers),
Week 15: Prototypes (OLEDs etc.), intermolecular bonding, Van der Waals.
Week 16: Electronic properties, polarization effects, Field effect Transistors, basics of excitonic solar cells.

Recommended Books:

1. A. Zangwill, "Physics at Surfaces", Cambridge University Press, 1988.
2. D. P. Woodruff and T. A. Delchar, "Modern Techniques of Surface Science", Cambridge University Press, 2nd ed. 1994.
3. D. Briggs and M. P. Seah, "Practical Surface Analysis", Vol-I, John Wiley, 2nd ed. 1990.
4. J. B. Hudson, "Surface Science, an Introduction", Wiley-Interscience, 1998.
5. H. Luth, "Surfaces and Interfaces of Solids", Springer-Verlag, 2nd ed. 1993.
6. M. Prutton, "Introduction to Surface Physics", Oxford University Press, 1994.
7. R. I. Masel, "Principles of Adsorption and Reaction on Solid Surfaces", Wiley-Interscience, 1996.

COMPUTATIONAL PHYSICS

Credit Hours:	**3 (3-0)**
Course Code:	**PHY-477**

Objective(s):
To introduce the students with computer languages and the use of computer in numerical analysis, computer simulations and modeling.
Learning Outcomes:
After studying this course the students will have clear understanding of computer languages and the use of computer in numerical analysis, computer simulations and modeling.

Week 1: Introduction to computational Physics
Week 2: Computer Languages,
Week 3: A brief introduction of the computer languages like Basic,

Week 4: C. Pascal etc. and known software packages of computation.
Week 5: Numerical Methods, Numerical Solutions of equations, Regression and interpolation,
Week 6: Numerical integration and differentiation.
Week 7: Error analysis and technique for elimination of systematic and random errors.
Week 8: Modeling & Simulations,
Week 9: Conceptual models, the mathematical models,
Week 10: Random numbers and random walk, doing Physics with random numbers,
Week 11: Computer simulation, Relationship of modeling and simulation.
Week 12: Some systems of interest for physicists such as Motion of Falling objects,
Week 13: Kepler's problems, Oscillatory motion, many particle systems,
Week 14: Dynamic systems, Wave phenomena, Field of static charges and current,
Week 15: Diffusion, Populations genetics etc.
Week 16: Developing programming skill with Physics problems.

Recommended Books:

1. M. L. De Jong, ”Introduction to Computational Physics”, Addison Wesley, 1991.
2. S. T. Koonini, “Computational Physics”, the Benjamin-Cummings, 1985.
3. H. Gould, J. Tobochnik and W. Christian, “An Introduction to Computer Simulation Methods”, Addison Wesley, 3rd ed. 2006.
4. S. C. Chapra and R. P. Chanle, ”Numerical Methods for Engineers with Personal Computer Applications”, McGraw-Hill,1990.
5. S. C. Chapra, “Applied Numerical Methods with MATLAB for Engineers and Scientists”, McGraw-Hill, 2nd ed. 2006.

CLAY SCIENCE

Pre-requisite: **Solid State Physics-I**
Credit Hours: **3 (3-0)**
Course Code: **PHY-478**

Objective(s):
The objective of this course is to study Clay Science, its applications and the use of various characterization techniques in Clay Science.

Learning Outcomes:
After studying this course the students will have clear understanding of the fundamental concepts used in Clay Science and its applications. The students will have also adequate knowledge about the various characterization techniques used in Clay Science.

Week 1: General Introduction: History of clay science, Aim and Scope of clay science, Clay.

Week 2: Clay Mineral, Distinction between clay and clay minerals, clay mineral properties, associated minerals, associated phases, other solids with similar properties.
Week 3: Clay mineral particle and aggregates, clay mineral and environments, Alternative concept of clay minerals, Clay science.
Week 4: Structure and Mineralogy of clay minerals: General structure information, Layer charge, polytypism, mixed layer structures,
Week 5: The 1:1 llayer: Dioctahedral 1:1 layer minerals (the kaolin group- kaolinite, Dickite, Nacrite,
Week 6: Halloysite, Hisingrite), Trioctahderal 1:1 minerals, the serpentine group, The 2:1 layer pyrophyllite, Talc,and related minerals, True and brittle mica, Illite, Smectite, Vermiculite, chlorite,
Week 7: Illite-smectite and other interstratifications between dioctahedral non-xepandable and expandiable 2:1 layers, Allophane and imogolite, polygroskite
Week 8: Surface and interface chemistry of clay minerals: Surface atoms, surface structures and properties, constant charge sites, the hydroxyl surface, clay water interactions,
Week 9: Structure and properties of sorbed to clay mineral surface, influence of water on clay mineral structure, surface chemistry in aqueous dispersions,
Week 10: Organization of clay mineral particles and molecules, Synthetic clay minerals and purification of natural clays: Methodology, Synthesis of specific clay minerals (like micas, smectites, kaolinite, sepolite),
Week 11: Purification of clays, purification procedures (decomposition of carbonates, recommended procedures, dissolution of (Hydro) oxides, oxidation of organic materials,
Week 12: Dissolution of silica, removal of remaining salt by dialysis and fractionation, a simplified gentle purification method, a pilot purification technique.
Week 13: Properties and modification of clays: General properties, water interaction, hydraulic conductivity, gas penetrability,
Week 14: Ion diffusivity, mechanical properties, acid activation, thermal modification, dehydroxylated phases, High temperature phases, Assessment of some analytical technique:
Week 15: X-ray absorption spectroscopy, X-ray photoelectron microscopy, Fourier transformation infrared spectroscopy, nuclear magnetic resonance microscopy,
Week 16: Scanning electron microscopy, XRD analysis, TEM, Thermal analysis

Main Text Book

1. F Bergaya, BKG Theng and G Lagaly, "Development in clay Science, 1, Handbook of clay Science", Elsever Ltd, 2006.

Reference books:

1. SW Bailey, "Volume 19: Hydrous Phyllosilicates (exclusive mics)", Mineralogical Society of America, 1988.
2. A K Chakarborty, "Phase Transformation of kaolinite clay", Springer India 2014.

3. V.S. Ramachandran, Ralph M. Paroli, James J. Beaudoin, and Ana H. Delgado, "Handbook of Thermal Analysis of Construction Materials", Noyes Publications, 2002.

Annexure "D"

COMPULSORY COURSES OF MATHMATICS IN BS PHYSICS (4 YEAR)

CALCULUS-I
Credit Hours: **3 (3-0)**
Course Code: **MTH-**
Objective(s):
This course services as the foundation of advance subjects in all areas of Physics. The purpose of this course is to prepare the students to have a basic understanding of various calculus concepts with the essential tools of calculus to apply the concepts and the techniques in their respective disciplines.
Learning Outcomes:

Upon completion of the course, the student will be able to: interpret various concepts of calculus like function from an algebraic, numerical, graphical and verbal perspective and extract information relevant to the phenomenon modeled by the various Calculus concepts

Week 1: Functions and graphs (shifting and stretching),
Week 2: Limits and continuity, differentiation (rates of change,
Week 3: Slope of the tangent to a curve, rules for differentiation,
Week 4: Chain rule, implicit differentiation, extrema of functions,
Week 5: Mean value theorem, simple problems in optimization,
Week 6: Use of derivatives in sketching, asymptotic behavior of functions, L'H'opital's rule), integration (indefinite integrals,
Week 7: Introduction to the idea of differential equations and their solution – the initial value problem, techniques of integration,
Week 8: Riemann sums and definite integrals,
Week 9: Physical interpretation as areas, mean value theorem, areas between curves,
Week 10: Finding volumes by slicing,
Week 11: Volumes of solids of revolution, arc lengths, areas of surfaces of revolution, centres of mass and higher moments, work),
Week 12: Differentiation and integration of transcendental functions (exponential and logarithmic functions and applications to growth and decay problems,
Week 13: Trigonometric and inverse trigonometric functions, hyperbolic functions),
Week 14: Infinite series (limits of sequences of numbers, series,
Week 15: Tests of convergence, power series,
Week 16: Taylor and Maclaurine series.

CALCULUS-II
Credit Hours: **3 (3-0)**
Course Code: **MTH-**
Objective(s):
To prepare the students to have a deeper understanding of various calculus theories with the essential tools of calculus to apply the concepts and the techniques in their respective disciplines. As continuation of Calculus I, it focuses on the study of various differential and integral theorems.
Learning Outcomes:
Studying this course students will be expected to know the fundamental theorem of calculus and be able to use it for evaluating various problems regarding calculus in hand.

Week 1: Introduction to basic calculus
Week 2: Motivation and geometric background (conic sections,
Week 3: **P**arameterized curves, polar coordinates, vectors and analytic geometry in space,
Week 4: Examples of vector fields in space relevant to physics),
Week 5: Partial derivatives (limits and continuity, partial derivatives,
Week 6: Chain rule, role of constraints,
Week 7: Directional derivatives – gradient vectors and tangent planes,
Week 8: Extrema and saddle points, Lagrange multipliers, Taylor's expansion of a multi-variable function),
Week 9: Multiple integrals (double and triple integrals,
Week 10: Centre of mass and higher moments, areas and volumes,
Week 11: Integration in spherical and cylindrical coordinate systems),
Week 12: Calculus of vector fields with emphasis on physical interpretation
Week 13: Line integrals and work, circulation and curl, conservative fields and gradients, surface and volume integrals,
Week 14: divergence of a vector field, Green's theorem in a plane,
Week 15: Stroke's theorem, divergence theorem).
Week 16: Problems solving

Recommended Books for CALCULUS (I& II)

1. G. B. Thomas, R. L. Finney, "Calculus and Analytic Geometry", National Book Foundation, 9th ed.
2. G. Strang, "Calculus", Wellesley-Cambridge, 2nd ed., 2010.
3. E. W. Swokowski, M. Olinick, D. Pence, and J. A. Cole, "Calculus"; Pws Pub Co; 6th ed. 1994.

LINEAR ALGEBRA
Credit Hours: **3 (3-0)**
Course Code: **MTH-**
Objective(s):
This is the course in vectors, matrices and linear algebra, which provides basic background needed for all mathematical physics. Many concepts presented in the course are based on the awareness of how linear algebra is applied.
Learning Outcomes:
On successful completion of this course students will be able to understand and solve systems of linear equations and to utilize the concepts of basic algebra to various problems in physics.

Week 1: Review of vectors in 3 dimensions (arrows) with a view of abstraction into properties of vector spaces in N dimensions (closure, associativity and commutativity of addition
Week 2: Existence of identity and inverse, distributivity of scalar multiplication),
Week 3: Idea of vector norm in 3 dimensions, orthogonality, expansion in a basis,
Week 4: Multiplication of vectors in 3 dimensions, applications of vector algebra to geometry and physics], vector spaces in N dimensions (definition, basis, inner product,
Week 5: Linear product operators, matrix algebra functions of matrices, transpose, complex and Hermitian conjugates, trace,
Week 6: Determinant, inverse, rank, special types of matrices diagonal, triangular, symmetric and antisymmetric, orthogonal,
Week 7: Hermitian and anti-Hermitian, unitary, normal, eigenvalue problem, similarity transformations and change of basis,
Week 8: Diagonalization, simultaneous linear equations), normal modes (oscillatory systems, elementary use of symmetries to guess normal modes, Rayleigh-Ritz method),
Week 9: Fourier series as an application of the ideas of linear algebra to the space of periodic functions (identification of the space of periodic functions of a certain period as a linear vector space,
Week 10: Identification of sinusoidal functions as basis vectors in this infinite dimensional vector space, properties of Fourier series, Parseval's theorem,
Week 11: Handling of non-functions via extending the domain of definition of function),
Week 12: Sets of functions, eigenvalue problem in the context of differential operators, adjoint and Hermitian operators,
Week 13: Properties of Hermitian operators (reality of eigenvalues, orthogonality of eigenfunctions, completeness of eigenfunctions - eigenbasis),
Week 14: Sturm-Lioville equations (Hermitian nature of Sturm-Lioville operator, transforming an equation into Sturm-Lioville form,
Week 15: Fourier-Legendre and Fourier-Bessel series).
Week 16: Miscellaneous problems solving.

Recommended Books:

1. K. F. Riley, M. P. Hobson and S. J. Bence, “Mathematical Methods for Physicists”, Cambridge University Press 2006.
2. Peter V. O'Neil, “Advanced Engineering Mathematics”, 7th ed. CL Engineering, 2011.
3. Advanced Mathematics. Schaum Series.
4. Intoduction to linear algebra, Stainly Grossman

ORDINARY DIFFERENTIAL EQUATIONS

Credit Hours: 3 (3-0)
Course Code: MTH-
Objective(s):
This course provides the foundation of all advanced subjects in Mathematics. Strong foundation and applications of Ordinary Differential Equations is the goal of the course.
Learning Outcomes:
On successful completion of this course students will be able to understand and solve systems of differential equations and to utilize the concepts of differentials to the practical problems in physics.

Week 1: Introduction to ODEs (physical motivation),
Week 2: First order ODEs (separable variables, homogeneous equations, exact equations,
Week 3: Linear equations, Bernoulli equation and other examples),
Week 4: Applications of first order ODEs linear and non-linear,
Week 5: Linear differential equations of higher order
Week 6: Initial value and boundary value problems,
Week 7: Linear dependence and independence, solutions of linear equations,
Week 8: Constructing a second solution from a known solution,
Week 9: Homogeneous linear equations with constant coefficients,
Week 10: Undetermined coefficients, variation of parameters), applications of second order ODEs (simple harmonic motion,
Week 11: Damped and forced oscillators, electrical circuits and springs),
Week 12: Differential equations with variable coefficients (Cauchy-Euler equation,
Week 13: Power series solution of differential equations
Week 14: Solutions about ordinary and singular points-Legendre's and Bessel's equations as examples), Laplace transform
Week 15: (Laplace transform and its inverse and properties, use in solving differential equations, Dirac delta function).
Week 16: Miscellaneous probleming solving

Recommended Books:
1. D. G. Zill and M. R. Cullen, "Differential Equations with Boundary Value Problems", 3rd ed. National Book Foundation.
2. E. Kreyszig, "Advanced Engineering Mathematics", John Wiley, 8th ed. 1999.
3. K. F. Riley, M. P. Hobson and S. J. Bence, "Mathematical Methods for Physicists", Cambridge University Press 2006.

Annexure "E"

COMPULSORY COURSES OF ENGLISH IN BS PHYSICS (4 YEAR)

ENGLISH-I
Credit Hours: **3 (3-0)**
Course Code: **ENG-**

Objectives:
To improve language skills and to develop critical thinking.
Learning Outcomes:
After studying this course contents, students will be able to communicate and enhance their mental faculties. They will easily express themselves in written and in spoken English.

Course Contents
Week 1: Basics of Grammar
Week 2: Parts of speech and use of articles
Week 3: Sentence structure,
Week 4: Active and passive voice
Week 5: Practice in unified sentence
Week 6: Analysis of phrase,
Week 7: Clause and sentence structure
Week 8: Transitive and intransitive verbs
Week 9: Punctuation and spelling
Week 10: Comprehension
Answers to questions on a given text
Week 11: Discussion
Week 12: General Topics and every-day conversation (topics for discussion to be at the discretion of the teacher keeping in view the level of students)
Week 13: Listening
To be improved by showing documentaries/films carefully selected by subject teachers
Week 14: Translation skills
Urdu to English
Week 15: Paragraph writing
Topics to be chosen at the discretion of the teacher
Week16 : Presentation skills
Introduction
Note: Extensive reading is required for vocabulary building

Recommended books:
1. Functional English

a) Grammar
1. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 1. Third edition. Oxford University, Press. 1997. ISBN 0194313492
2. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2. Third edition. Oxford University Press. 1997. ISBN 0194313506
b) Writing
1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 0 19 435405 7 Pages 20-27 and 35-41.
c) Reading/Comprehension
1. Reading. Upper Intermediate. Brain Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 453402 2.
d) Speaking

ENGLISH-II
Credit Hours: **3 (3-0)**
Course Code: **ENG-**

Objectives:
Enable the students to meet their real life communication needs.
Learning Outcomes:
Studying this course contents will help and guide students to achieve their goals in practical life and job orientations. They will make progress in real life situation face by them.
Course Contents
Week 1-2: Paragraph writing
Practice in writing a good, unified and coherent paragraph
Week 3-4: Essay writing
Introduction
Week 5-6: CV and job application
Translation skills
Urdu to English
Week 7-10: Study skills
Skimming and scanning, intensive and extensive, and speed reading, summary and précis writing and comprehension
Week 11-13: Academic skills
Letter/memo writing, minutes of meetings, use of library and internet
Week 14-16: Presentation skills
Personality development (emphasis on content, style and pronunciation)
Note: documentaries to be shown for discussion and review
Recommended books:

Communication Skills
a) Grammar
1. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2. Third edition. Oxford University Press 1986. ISBN 0 19 431350 6.
b) Writing
1. Writing. Intermediate by Marie-Chrisitine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 019 435405 7 Pages 45-53 (note taking).
2. Writing. Upper-Intermediate by Rob Nolasco. Oxford Supplementary Skills. Fourth Impression 1992. ISBN 0 19 435406 5 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).
c) Reading
1. Reading. Advanced. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1991.ISBN 0 19 453403 0.
2. Reading and Study Skills by John Langan
3. Study Skills by Riachard Yorky.

ENGLISH-III
Credit Hours: **3 (3-0)**
Course Code: **ENG-**

Objectives: Enhance language skills and develop critical thinking.
Learning Outcomes:
While studying this course contents students will become sharp and broad minded. They will be able to write good research proposal, articles needed or required in academic environment**.**

Course Contents
Week 1-4: Presentation skills
Week 5-8: Essay writing
Descriptive, narrative, discursive, argumentative
Week 9-10: Academic writing
How to write a proposal for research paper/term paper
How to write a research paper/term paper (emphasis on style, content, language, form, clarity, consistency)
Week 11-12: Technical Report writing
Week 13-16: Progress report writing
Note: Extensive reading is required for vocabulary building
Recommended books:
Technical Writing and Presentation Skills
a) Essay Writing and Academic Writing

1. Writing. Advanced by Ron White. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 435407 3 (particularly suitable for discursive, descriptive, argumentative and Report writing).
2. College Writing Skills by John Langan. Mc=Graw-Hill Higher Education. 2004.
3. Patterns of College Writing (4th edition) by Laurie G. Kirszner and Stephen R. Mandell. St. Martin's Press.

b) Presentation Skills

c) Reading

The Mercury Reader. A Custom Publication. Compiled by norther Illinois University. General Editiors: Janice Neulib; Kathleen Shine Cain; Stephen Ruffus and Maurice Scharton. (A reader which will give students exposure to the best of twentieth century literature, without taxing the taste of engineering students).

ENGLISH-IV
Credit Hours: **3 (3-0)**
Course Code: **ENG-**

Objectives:
To develop critical thinking and reasoning of students and their analytical approach towards readings.

Learning Outcomes:
To be human is to think, and critical thinking is thinking about thinking, which is not common to everyone. Studying this course students approach towards readings becomes analytical and profound.

Week 1-2: Read Academics text critically
Week 3-4: Write well organized academic text e.g. assignments, examination answers
Week 5-6: Write narrative, descriptive, argumentative essays and reports (assignments)
Contents:
Week 7-8: Critical Reading Advanced reading skills and strategies building on Foundations of English I & II courses in semesters I and II of a range of text types e.g. description, argumentation, comparison and contrast.
Week 9-10: Advanced Academic Writing Advanced writing skills and strategies building on English I & II in semesters I and II respectively
Week 11-12: Writing summaries of articles, report writing
Week 13-14: Analysis and synthesis of academic material in writing
Week 15-16: Presenting an argument in assignments/term-papers and examination answers

Recommended Books:
1. Aaron, J. 2003. The Compact Reader. New York: Bedford.

2. Axelrod, R. B and Cooper, C. R. 2002. Reading Critical Writing Well: A Reader and Guide.
3. Barnet, S. and Bedau, H. 2004. Critical Thinking, Reading and Writing: A Brief Guide to Writing. 6 th Ed.
4. Behrens & Rosen. 2007. Reading and Writing Across the Curriculum.
5. Gardner, P. S. 2005. New Directions: Reading, Writing and Critical Thinking.
6. George, D. and Trimbur, J. 2006. Reading Culture: Context for Critical Reading and Writing. 6th Ed.
7. Goatly, A. 2000. Critical Reading and Writing: An Introductory Course. London: Taylor & Francis.
8. Grellet, F., Writing for Advanced Learners of English. CUP.
9. Jordan, K. M. and Plakans, L. 2003. Reading and Writing for Academic Success.
10. Jordon, R. R. 1999. Academic Writing Course. CUP. 11.
Smith, L. C. 2003. Issues for Today: An Effective Reading Skills Text 12. Withrow, J., Effective Writing.

ISLAMIC STUDIES (Compulsory)
Credit Hours: **2 (2-0)**
Course Code: **ISL-**

Objectives:

This course is aimed at:

1. To provide Basic information about Islamic Studies
2. To enhance understanding regarding Islamic Civilization
3. To improve Students skill to perform prayers and other worships
4. To enhance the skill of the students for understanding of issues related to faith and religious life.

Learning Outcomes:

Studying this course will provide the students basic information about Islamic Studies, understanding about Islamic Civilization and will enhance the skill of the students for understanding of issues related to faith and religious life.

Detail of Course

Introduction to Quranic Studies

1) Basic Concepts of Quran
2) History of Quran
3) Uloom-ul -Quran

Week 1: Study of Selected Text of Holly Quran

1) Verses of Surah Al-Baqra Related to Faith(Verse No-284-286)
2) Verses of Surah Al-Hujrat Related to Adab Al-Nabi (Verse No-1-18)
3) Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11)
4) Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77)
5) Verses of Surah Al-Inam Related to Ihkam(Verse No-152-154)

Week 2: Study of Sellected Text of Holly Quran

1) Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No.6,21,40,56,57,58.)
2) Verses of Surah Al-Hashar (18,19,20) Related to thinking, Day of Judgment
3) Verses of Surah Al-Saf Related to Tafakar,Tadabar (Verse No- 1,14)

Week 3: Seerat of Holy Prophet (S.A.W) I

1) Life of Muhammad Bin Abdullah (Before Prophet Hood)
2) Life of Holy Prophet (S.A.W) in Makkah
3) Important Lessons Derived from the life of Holy Prophet in Makkah

Week 4: Seerat of Holy Prophet (S.A.W) II

1) Life of Holy Prophet (S.A.W) in Madina

2) Important Events of Life Holy Prophet in Madina
3) Important Lessons Derived from the life of Holy Prophet in Madina

Week 5-6: Introduction To Sunnah
1) Basic Concepts of Hadith
2) History of Hadith
3) Kinds of Hadith
4) Uloom –ul-Hadith
5) Sunnah & Hadith
6) Legal Position of Sunnah

Selected Study from Text of Hadith

Week 7: Introduction to Islamic Law & Jurisprudence
1) Basic Concepts of Islamic Law & Jurisprudence
2) History & Importance of Islamic Law & Jurisprudence
3) Sources of Islamic Law & Jurisprudence
4) Nature of Differences in Islamic Law
5) Islam and Sectarianism

Week 8: Islamic Culture & Civilization
1) Basic Concepts of Islamic Culture & Civilization
2) Historical Development of Islamic Culture & Civilization
3) Characteristics of Islamic Culture & Civilization
4) Islamic Culture & Civilization and Contemporary Issues

Week 9: Islam & Science
1) Basic Concepts of Islam & Science
2) Contributions of Muslims in the Development of Science
3) Quranic & Science

Week 10: Islamic Economic System
1) Basic Concepts of Islamic Economic System
2) Means of Distribution of wealth in Islamic Economics
3) Islamic Concept of Riba
4) Islamic Ways of Trade & Commerce

Week 11-12: Political System of Islam
1) Basic Concepts of Islamic Political System
2) Islamic Concept of Sovereignty

3) Basic Institutions of Govt. in Islam

Week 13-14: Islamic History
1) Period of Khlaft-E-Rashida
2) Period of Ummayyads
3) Period of Abbasids

Week 15-16: Social System of Islam
1) Basic Concepts Of Social System Of Islam
2) Elements Of Family
3) Ethical Values Of Islam

Recommended Books:
1) Hameed ullah Muhammad, "Emergence of Islam" , IRI, Islamabad
2) Hameed ullah Muhammad, "Muslim Conduct of State"
3) Hameed ullah Muhammad, 'Introduction to Islam
4) Mulana Muhammad Yousaf Islahi,"
5) Hussain Hamid Hassan, "An Introduction to the Study of Islamic Law" leaf Publication Islamabad, Pakistan.
6) Ahmad Hasan, "Principles of Islamic Jurisprudence" Islamic Research Institute, International Islamic University, Islamabad (1993)
7) Mir Waliullah, "Muslim Jrisprudence and the Quranic Law of Crimes" Islamic Book Service (1982)
8) H.S. Bhatia, "Studies in Islamic Law, Religion and Society" Deep & Deep Publications New Delhi (1989)
9) Dr. Muhammad Zia-ul-Haq, "Introduction to Al Sharia Al Islamia" Allama Iqbal Open University, Islamabad (2001)

PAK STUDY (Compulsory)
Credit Hours: **2 (2-0)**
Course Code: **PKS-**
Objectives
1. To develop vision of historical perspective, government, politics, contemporary Pakistan, ideological background of Pakistan.
2. To study the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.
Learning Outcomes:
After studying this course the students will have a clear vision about historical perspective, government, politics, contemporary Pakistan, ideological background of Pakistan. They will

have also adequate knowledge about the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.

Course Outline

Week 1-4: Historical Perspective, Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-i-Azam Muhammad Ali Jinnah, Factors leading to Muslim separatism, People and Land

Week 5-6: Indus Civilization, Muslim advent, Location and geo-physical features.

Week 7-8: Government and Politics in Pakistan, Political and constitutional phases:, 1947-58, 1958-71, 1971-77

Week 9-10: 1977-88, 1988-99, 1999 onward

Week 11-13: Contemporary Pakistan, Economic institutions and issues, Society and social structure, Ethnicity

Week 14-16: Foreign policy of Pakistan and challenges, Futuristic outlook of Pakistan

Books Recommended

1. Burki, Shahid Javed. *State & Society in Pakistan,* The Macmillan Press Ltd 1980.
2. Akbar, S. Zaidi. *Issue in Pakistan's Economy.* Karachi: Oxford University Press, 2000.
3. S.M. Burke and Lawrence Ziring. Pakistan's Foreign policy: AnHistorical analysis. Karachi: Oxford University Press, 1993.
4. Mehmood, Safdar. *Pakistan Political Roots & Development.* Lahore, 1994.
5. Wilcox, Wayne.*The Emergence of Banglades.,* Washington: American Enterprise, Institute of Public Policy Research, 1972.
6. Mehmood, Safdar. *Pakistan Kayyun Toota,* Lahore: Idara-eSaqafat-e-Islamia, Club Road, nd.
7. Amin, Tahir. *Ethno - National Movement in Pakistan,* Islamabad: Institute of Policy Studies, Islamabad.
8. Ziring, Lawrence. *Enigma of Political Development.* Kent England: WmDawson & sons Ltd, 1980.
9. Zahid, Ansar. *History & Culture of Sindh.* Karachi: Royal Book Company, 1980.
10. Afzal, M. Rafique. *Political Parties in Pakistan,* Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research, 1998.
11. Sayeed, Khalid Bin. *The Political System of Pakistan.* Boston: Houghton Mifflin, 1967.
12. Aziz, K.K. *Party, Politics in Pakistan,* Islamabad: National Commission on Historical and Cultural Research, 1976.
13. Muhammad Waseem, Pakistan Under Martial Law, Lahore: Vanguard, 1987.
14. Haq, Noor ul. *Making of Pakistan: The Military Perspective.* Islamabad: National Commission on Historical and Cultural Research, 1993.

Annexure "F"

GRF COURSES FOR BS PHYSICS (4 YEAR) PROGRAM

STATISTICS-I
Credit Hours: 3 (3-0)
Course Code: STA-

Objectives:
This course helps students to understand the basic concepts of statistics, its nature, scope and importance with special focus on its use in basic sciences.
Learning Outcomes:
After studying this course the students will have clear understanding of the basic concepts of statistics, its nature, scope and importance with special focus on its use in basic sciences.

Week 1: Definition of Statistics, Population, sample Descriptive and inferential Statistics, Observations, Data, Discrete and continuous variables, Errors of measurement, Significant digits, Rounding of a Number, Collection of primary and secondary data, Sources, Editing of Data. Exercises.
Week 2: Introduction, basic principles of classification and Tabulation, Constructing of a frequency distribution, Relative and Cumulative frequency distribution,
Week 3: Diagrams, Graphs and their Construction, Bar charts, Pie chart, Histogram, Frequency polygon and Frequency curve, Cumulative Frequency Polygon or Ogive, Histogram, Ogive for Discrete Variable. Types of frequency curves. Exercises.
Week 4: Introduction, Different types of Averages, Quantiles, The Mode, Empirical Relation between Mean, Median and mode,
Week 5: Relative Merits and Demerits of various Averages. properties of Good Average, Box and Whisker Plot, Stem and Leaf Display, definition of outliers and their detection. Exercises.
Week 6: Introduction, Absolute and relative measures, Range, The semi-Inter- quartile Range, The Mean Deviation, The Variance and standard deviation
Week 7: Change of origin and scale, Interpretation of the standard Deviation, Coefficient of variation, Properties of variance and standard Deviation, Standardized variables, Moments and Moments ratios. Exercises.
Week 8: Discrete and continuous distributions: Binomial, Poisson and Normal Distribution. Exercises
Week 9: Introduction, sample design and sampling frame, bias, sampling and non-sampling errors, sampling with and without replacement, probability and non-probability sampling, Sampling distributions for single mean and proportion, Difference of means and proportions. Exercises.

Week 10: Introduction, Statistical problem, null and alternative hypothesis, Type-I and Type-II errors, level of significance, Test statistics, acceptance and rejection regions, general procedure for testing of hypothesis. Exercises.
Week 11: Introduction, Testing of hypothesis and confidence interval about the population mean and proportion for small and large samples, Exercises
Week 12: Introduction, Testing of hypothesis and confidence intervals about the difference of population means and proportions for small and large samples,
Week 13: Analysis of Variance and ANOVA Table. Exercises
Week 14: Introduction, Contingency Tables, Testing of hypothesis about the Independence of attributes. Exercises.
Week 15: Introduction, cause and effect relationships, examples, simple linear regression, estimation of parameters and their interpretation. r and R2. Correlation.
Week 16: Coefficient of linear correlation, its estimation and interpretation. Multiple regression and interpretation of its parameters. Examples
Recommended Books:

1 Walpole, R. E. 1982. "Introduction to Statistics", 3rd Ed., Macmillan Publishing Co., Inc. New York.

2 Muhammad, F. 2005. "Statistical Methods and Data Analysis", Kitab Markaz, Bhawana Bazar, Faisalabad.

CHEMISTRY-I

Credit Hours: **3 (3-0)**
Course Code: **CHE-**

Objectives:
Prepare the students with tools of Chemistry to apply the concepts and the techniques in their respective discipline.
Learning Outcomes: After studying this course the students will learn basic tools of chemistry to apply the concepts and techniques in their respective discipline.

Week 1: Atomic structure, Periodic table and atomic properties
Week 2: Types of Chemical Bonding, Gaseous and Liquid states of matter
Nature of covalent bond, Lewis structure, bond length
Week 3: bond angles and bond energies, localized and delocalized bonding resonance
Week 4: valence band theory and molecular orbital concepts
Week 5: hybridization, Sp^3, Sp^2 and Sp orbital.
Week 6: Dipole moments, inductive and resonance effects
Week 7: rules for relative contribution from different resonance structures

Week 8-9: Modern concepts using mathematics for understanding the principles
Week 10: Fundamental laws, Atomic molecular structures
Week 11-13 states of matter, Equilibrium
Week 14-15: Kinetic and elementary inorganic, organic and nuclear chemistry
Week 16: introduction to physical chemistry.

Recommended Books:

1. Physical Chemistry by W.J. Moore, Prentice Hall College Div; 4th edition, June 1972
2. Basic Inorganic Chemistry by Cotton Wilkinson LeGain 3rd Edition , 1995
3. Organic Chemistry by T.R Morrison and R.N Boyd Allyn and Bacon Inc. Longman Higher Education Division (a Pearson Education company) January 1, 1979
4. Organic Chemistry by Khairat & Rahman, The Carvan Book House

INTRODUCTION TO PROGRAMMING FOR PHYSICISTS

Credit Hours: **3 (3-0)**
Course Code: **CSC-**
Objectives:

This course aims to familiarize students with the fundamental concepts of computer programming and program execution and to enable the student to develop simple computer programs.

Learning Outcomes:
After studying this course the students will have fundamental concepts of computer programming and program execution. The students will also be able to develop simple computer programs.

Week 1-4: Introduction to programming, Significance of computers in the present physical sciences scenario, Software and hardware domains, Scientific computing, high and low level languages, flow charts, scientific programming languages, C/C++ and other scientific

Week 5-6: Programming language, Memory management in C++, structure of C++ program, Generic form, Header files, Constants,

Week 7-8: Local variables, Input/output statements, Simple program, Variables, Data types, variables, Operators, Loops, Break, Continue,

Week 9-10: If and if-else statements, Conditional operator, Switch statement, Flags and conditional testing, One-dimensional arrays,

Week 11-12: Multi-dimensional arrays, String manipulation functions, Arrays as lists, Sorting, Searching, functions, built-in and user defined functions,

Week 13-16: File system, pointer, inheritance, polymorphism, C++ for scientific programming. Lab work.

Recommended Books:

1. Deitel H M and P J Deitel, 2012, *C++ How to Program, 8/e, Early Objects Version*, Prentice Hall
2. Robert Lafore, 2002, Object-oriented Programming in C++, Ed. 4th, SAMS publishers.
3. Robert L, TURBO C++, 1991, Waite Group.
4. Harrison S P and G Steele Jr. 1987, C: A Reference Manual, Prentice-Hall.
5. Peter Norton, Introduction to computers, 6th Ed., McGraw Hill International Edition.

BASIC MATHEMATICS

Credit Hours: **3 (3-0)**
Course Code: **MTH-**
Objectives: This course is designed for the Pre-Medical students admitted in BS Physics, in order to introduce the basic mathematical concepts.
Learning Outcomes: Studying this course will enable the students to understand the basic mathematical concepts necessary for their studies in BS Physics.

Week 1-4: Matrices and Determinants. Complex Numbers
Week 5-6: Mathematical Induction and Binomial Theorem, Function and Graphs
Week 7-8: Trigonometric Identities, Function and Solution of Trigonometric Equations
Week 9-10: Ordinary differentiation, Ordinary integration, Higher order derivative
Week 11-12: limits and continuity, Integrations
Week 13-14: Conics-I and Conics-II
Week 15-16: Miscellaneous Problems solving.
Recommended Books: Text Books of Mathematics for F.Sc. Part 1 & II.

Annexure "G"

GOF COURSES FOR BS PHYSICS (4 YEAR) PROGRAM

INTRODUCTORY ECONOMICS

Credit Hours: **3 (3-0)**
Course Code: **ECO-**

Objectives:
The course is designed for the beginners with either no formal background or very little acquaintance with economics. The objective is to give the students with a clear understanding of the basic concepts, tools of analysis and terminologies used in microeconomics & Macro Economics, Emphasis will be on the use of graphs, diagrams and numerical tables/schedules for exposition. The teacher is expected to draw examples from the surrounding world to clarify the concepts.

Learning Outcomes:
After studying this course the students will have a clear understanding of the basic concepts, tools of analysis and terminologies used in microeconomics & Macro Economics.

Week 1-2: The study of the price system and resource allocation
Week 3-4: Problems of monopoly,
Week 5-6: The role of government in regulating and supplementing the price system.
Week 7-8: Market forces i.e. demand and supply which play pivotal role in markets are discussed with special emphasis on product market and factor market.
Week 9-10: The study of total output and employment, Inflation,
Week 11-12: Economic growth, Introduction to international trade and development.
Week 13-14: Fiscal policy, monetary policy,
Week 15-16: Price policy, International trade policy are covered completely, keeping in mind the overall macro level environment of the economy.

Recommended Books

1. Mankiw, G. - Principles of Economics - 2nd Edition (2001), South-West Publishers.
2. Samuelson and Nordrons - Economics –18th Edition (2004)- McGraw Hill.
3. McConnell and Bruce - Principles of Economics -17th Edition (2006)- McGraw Hill.
4. Lipsey and Goerant-Principles of Economics-10th Edition (2003)- Oxford University Press
5. Mankiw, G–Principles of Economics-2nd Edition (2001) - South-West Publishers.
6. Samuelsson and Nordrons - Economics –18th Edition (2004) - McGraw Hill. Inc.
7. Parkin, Michael - Macroeconomics, 7th Edition (2004) - Prentice Hall.
8. Miller, R.L. – Economics Today -14th Edition (2005) – Addison Wesley.

PRINCIPLES OF MANAGEMENT

Credit Hours: 3 (3-0)
Course Code: MAN-

Objectives:
This course aims at broadening the perspective of the students to understand management of an organization including various managerial functions and giving them insight into various managerial skills.

Learning Outcomes:
After studying this course the students will have a clear understanding about the management of an organization including various managerial functions. This course will also give them an insight into various managerial skills.
basic concepts, tools of analysis and terminologies used in microeconomics & Macro Economics

Week 1: Definition of Management, nature and purpose, Management Skills,
Week 2: Technical, Human, Conceptual, Design**,** Productivity, effectiveness and efficiency**,**
Week 3: Managing science or art, elements of science, scientific approach**,** Functions of managers, planning, organizing, leading, staffing, controlling
Week 4: Fredrick Taylor, Taylor's major concern, Taylor's principles**,** Fayol's operational management**,**
Week 5: Fayol's 14 principles**,** Hawthorne studies, behavior management
Week 6: Nature and purpose of planning**,** Definition**,** Nature, contribution to purpose and objectives, primacy, pervasiveness, efficiency,
Week 7: Types of plans, mission, objectives, strategies, policies, procedures**,** Steps in planning process**,** MBO-process, setting preliminary objectives,
Week 8: clarify roles, subordinate objectives**,** Benefits of MBO**,** Weakness of MBO
Week 9: Formal and informal organization**,** Span of management**,** Factors determining effective span**,** Structure, logic and purpose of organizing
Week 10: By time, by function, by geography, by customer, by product, Human resource management,
Week 11: Definition of staffing, Selection process, techniques and instruments, Selection process,
Week 12: interviews, tests, assessment centers, limitations, Socializing new employees
Week 13-14: Leadership, Definition, Leadership behavior and styles, Linkert's four system approaches, Managerial grid
Week 15-16: Steps in control process, establishment of standards, measurement of performance, Corrections of deviations

Recommended Books:

1. Heinz Weihrich, Harold Koontz: "*Management- a global perspective*"

10th Edition. McGraw Hill Series (Jan 1986)

2. Joseph M. Putty: “*Management- a functional approach*”

INTRODUCTION TO SOCIOLOGY

Credit Hours: **3 (3-0)**
Course Code: **SOC-**

Objectives:

The course is designed to introduce the students with sociological concepts and the discipline. The focus of the course shall be on significant concepts like social systems and structures, socio-economic changes and social processes. The course will provide due foundation for further studies in the field of sociology.

Learning Outcomes:
After studying this course the students will come to know about the sociological concepts. The students will also have clear focus on significant concepts like social systems and structures, socio-economic changes and social processes.

Course Contents

Week 1: Introduction, Definition, Scope, and Subject Matter, Sociology as a Science ,Historical back ground of Sociology
Week 2: Basic Concepts, Group, Community, Society, Associations, Non-Voluntary, Voluntary
Week 3: Organization, Informal, Formal
Week 4: Social Interaction, Levels of Social Interaction
Week 5: Process of Social Interaction ,Cooperation, Competition, Conflict, Accommodation, Acculturation and diffusion, Assimilation, Amalgamation
Week 6: Social Groups, Definition & Functions
Week 7: Types of social groups, In and out groups , Primary and Secondary group , Reference groups, Informal and Formal groups , Pressure groups
Week 8: Culture, Definition, aspects and characteristics of Culture
Week 9: Material and non material culture, Ideal and real culture
Week 10: Elements of culture, Beliefs, Values, Norms and social sanctions
Week 11: Organizations of culture, Traits, Complexes, Patterns, Ethos, Theme
Week 12: Other related concepts, Cultural Relativism , Sub Cultures, Ethnocentrism and Xenocentrism, Cultural lag
Week 13: Socialization & Personality , Personality, Factors in Personality Formation , Socialization, Agencies of Socialization, Role & Status
Week 14: Deviance and Social Control, Deviance and its types , Social control and its need, Forms of Social control, Methods & Agencies of Social control
Week 15: Collective Behavior, Collective behavior, its types,
Week 16: Crowd behavior, Public opinion, Propaganda , Social movements, Leadership

Recommended Books:

1. Anderson, Margaret and Howard F. Taylor. 2001. Sociology the Essentials. Australia: Wadsworth.
2. Brown, Ken 2004. Sociology. UK: Polity Press
3. Gidden, Anthony 2002. Introduction to Sociology. UK: Polity Press.
4. Macionis, John J. 2006. 10th Edition Sociology New Jersey: Prentice-Hall
5. Tischler, Henry L. 2002. Introduction to Sociology 7th ed. New York: The Harcourt Press.
6. Frank N Magill. 2003. International Encyclopedia of Sociology. U.S.A: Fitzroy Dearborn Publishers
7. Macionis, John J. 2005. Sociology 10th ed. South Asia: Pearson Education
8. Kerbo, Harold R. 1989. Sociology: Social Structure and Social Conflict. New York: Macmillan Publishing Company.
9. Koening Samuel. 1957. Sociology: An Introduction to the Science of Society. New York: Barnes and Nobel..
10. Lee, Alfred Mclung and Lee, Elizabeth Briant 1961. Marriage and The family. New York: Barnes and Noble, Inc.
11. Leslie, Gerald et al. 1973. Order and Change: Introductory Sociology Toronto: Oxford University Press.
12. Lenski, Gevbard and Lenski, Jeam. 1982. Human Societies. 4th edition New York: McGraw-Hill Book Company.
13. James M. Henslin. 2004. Sociology: A Down to Earth Approach. Toronto: Allen and Bacon.

INTRODUCTION TO PSYCHOLOGY

Credit Hours: **3 (3-0)**
Course Code: **PSY-**

Objectives:

Describe psychology with major areas in the field, and identify the parameters of this discipline. Distinguish between the major perspectives on human thought and behavior. Appreciate the variety of ways psychological data are gathered and evaluated. Gain insight into human behavior and into one's own personality or personal relationships. Explore the ways that psychological theories are used to describe, understand, predict, and control or modify behavior.

Learning Outcomes:

After studying this course the students will come to know about the parameters of this discipline. They will be able to distinguish between the major perspectives on human thought and behavior. They will Gain insight into human behavior and into one's own personality or personal relationships. They will explore the ways the psychological theories are used to describe, understand, predict, and control or modify behavior.

Course Contents

Week 1: Introduction to Psychology, Nature and Application of Psychology with special reference to Pakistan, Historical Background and Schools of Psychology (A Brief Survey)

Week 2: Methods of Psychology, Observation, Case History Method Experimental Method, Survey Method, Interviewing Techniques

Week 3: Biological Basis of Behavior, Neuron: Structure and Functions, Central Nervous System and Peripheral Nervous System, Endocrine Glands

Week 4: Sensation, Perception and Attention, Sensation, Characteristics and Major Functions of Different Sensations, Vision: Structure and functions of the Eye, Audition: Structure and functions of the Ear.

Week 5: Perception, Nature of Perception, Factors of Perception: Subjective, Objective and Social, Kinds of Perception,

Week 6: Spatial Perception (Perception of Depth and Distance), Temporal Perception; **Week :** Auditory Perception, Attention, Factors, Subjective and Objective, Span of Attention, Fluctuation of Attention, Distraction of Attention (Causes and Control)

Week 7: Motives, Definition and Nature, Classification Primary(Biogenic) Motives: Hunger, Thirst, Defection and Urination, Fatigue, Sleep, Pain, Temperature, Regulation,

Week 8: Maternal Behavior, Sex Secondary (Sociogenic) Motives:Play and Manipulation, Exploration and Curiosity, Affiliation,

Week 9: Achievement and Power, Competition, Cooperation, Social Approval and Self Actualization.

Week 10: Emotions, Definition and Nature, Physiological changes during Emotions (Neural, Cardial, Visceral, Glandular)

Week 11: Galvanic Skin Response; Pupilliometrics, Theories of Emotion, James Lange Theory; Cannon-Bard Theory, Schechter –Singer Theory

Week 12: Learning, Definition of Learning, Types of Learning: Classical and Operant Conditioning Methods of Learning: Trial and Error; Learning by Insight; Observational Learning

Week 13: Memory, Definition and Nature, Memory Processes: Retention, Recall and Recognition, Forgetting: Nature and Causes

Week 14: Thinking, Definition and Nature, Tools of Thinking: Imagery; Language; Concepts, Kinds of Thinking, Problem Solving; Decision Making; Reasoning

Week 15: Individual differences, Definition concepts of, Intelligence,

Week 16:personality, aptitude, achievement

Recommended Books

1. Atkinson R. C., & Smith E. E. (2000). Introduction to psychology(13thed.). Harcourt Brace College Publishers.
2. Fernald, L.D., &Fernald, P.S.(2005). Introduction to psychology. USA: WMCBrown Publishers.
3. Glassman, W. E. (2000). Approaches to psychology. Open University Press. Hayes, N. (2000). Foundation of psychology (3rded.). Thomson Learning. Lahey, B. B. (2004).

Psychology: An introduction (8th ed.). McGraw-HillCompanies, Inc.
4. Leahey, T. H. (1992). A history of psychology: Main currents in psychological thought. New Jersey: Prentice-Hall International, Inc.
5. Myers, D. G. (1992).Psychology. (3rd ed.). New York: WadsworthPublishers.
6. Ormord, J. E. (1995). Educational psychology: Developing learners. Prentice- Hall, Inc.

Annexure "H"

LABORATORY COURSES IN BS PHYSICS (4YEAR) PROGRAM

Students will take seven laboratory courses, Lab-I through Lab VII. Labs I, II, III and IV are one credit hour each while Labs V, VI and VII are two credit hours. The learning outcomes of the laboratory courses are given below:

Mathematical and conceptual outcomes:

1. Demonstrate a keen appreciation of physical quantities, their dimensions and units.
2. Perform simple statistical analysis of data including calculating means, mean squares, root mean squares, standard deviations and correlations between groups of data.
3. Mathematically understand physical processes and fitting them with linear, exponential, sinusoidal and polynomial models.
4. Accurately represent experimental data in the form of tables and graphs.
5. Understand errors, uncertainties and their propagation from basic to deduced quantities. Students must possess the ability to calculate uncertainties and appreciate types A and B of uncertainties. Students must appreciate when experiments are repeatable and reproducible, determine and understand the concepts of precision and accuracy, resolution and time for measurement.
6. Students must be able to develop a keen sense of measurement theory in accordance with the guidelines presented in the "Guide to the Expression of Uncertainties in Measurement" as formulated by ISO's Joint Committee for Guides in Metrology (as of November 2012, these guides are downloadable from http://www.iso.org/sites/JCGM/GUMintroduction.htm).
7. Students must possess the ability to present an idea in the following equivalent forms: (a) equations and formulas, (b) words, (c) graphs, (d) pictures and sketches.
8. Develop an appreciation of energy, its myriad manifestations and inter-conversion.

Engineering and Practical Outcomes:

1. Perform experiments to test physical ideas, corroborate physical theories, find correspondence between theory and experiment, understand the limitations of theoretical descriptions and the role of approximations in physics.
2. Design simple experiments to test physical ideas.

3. Understand the significance of various kinds of materials (ceramics, plastics, metals, conductors, insulators) in the design of hardware.
4. Perform experiments safely.
5. Demonstrate the ability to work in teams.
6. Use locally available resources including materials and craftsmanship to build new projects.
7. Familiarity with mechanical workshop and ability to interpret basic engineering drawings.
8. Specializing in the skill of logging laboratory activity and producing high quality reports of experimental work.
9. Obtaining basic familiarity with advanced scientific instrumentation and its role in the progress of physics and science. Students must also possess the appreciation of limitations in accuracy and precision of the apparatus they use and the ability to suggest improvements in the equipment, the experimental procedure and the processing of data.
10. Students should be invariably introduced at some stage during the lab courses to these modern techniques that have now become routine in laboratories worldwide: (a) data acquisition which is the transfer of experimental data from the physical apparatus to the computer using analog-to-digital converters, (b) use of some modern software (e.g. Matlab, Origin, Mathematica, C++) for statistical processing and presentation of data.

Institutes can develop the contents of the laboratory courses dependent on the facilities and equipment available and committed resources. The guidelines that follow are in line with best practices and holistically map with the scheme of studies for the four year BS Physics programme outlined in the previous pages.

The learning outcomes enumerated above are to be addressed throughout all the laboratory courses and are not specific to a particular course. It is the role of the institute to ensure that these outcomes are adequately achieved and the assessment and student grading is conducted in accordance with the outcomes.

Also note that a one-credit hour laboratory entails at least three hours of practical work each week during the semester and a two-credit hour laboratory requires at least six hours of practical work each week.

Course	Semester	Credit Hours	Themes
Lab-I	1	1	• Measurement and uncertainties • Mechanics, fluids
Lab-II	2	1	• Measurement and uncertainties • Electricity and Magnetism
Lab-III	3	1	• Heat, waves, sound
Lab-IV	4	1	• Optics
Lab-V	5	2	• electronics
Lab-VI	6	2	• Modern Physics • Advanced optics, atomic physics and spectroscopy Electronic materials
Lab-VII	7	2	• Miscellaneous advanced experiments in modern physics, atomic physics, solid state physics, electronics

Sample experiments and areas of exploration for various themes are listed here.

Mechanics and Fluids: experiments with pendulums, stop watches, one dimensional motion and verification of Newton's laws of motion, measurement of forces, speed, acceleration and linear momentum, collisions and conservation of momentum, impacts, free fall and acceleration due to gravity, gyroscopes, rotational motion, conservation of angular momentum, friction, static and dynamic equilibrium, compound pendulum, rolling motion along inclined planes, simple harmonic motion, masses attached to springs and Hooke's law, damped motion and the regimes of damping (overdamped, underdamped and critically damped), pressure in fluids, experiments demonstrating continuity, Bernoulli's principle, buoyancy and Archimedes' principle, Atwood machine, fluid viscosity, surface tension.

Electricity and Magnetism: Static charge and electric fields, direct and alternating currents, electrical measurement instrumentation (voltmeters, ammeters, power supplies, variable transformers, cathode ray oscilloscope, electrometer), passive electronic components (resistors, capacitors, inductors), measurement of resistance, capacitance and inductance, electromagnetic induction, inductors and transformers, motors, magnetic fields due to currents and permanent magnets, ferromagnetism and ferroelectricity, determination of hysteresis curves, determination of Curie point, magnetic susceptibility and its temperature dependence, dielectric properties measurement, mapping of magnetic fields using Hall sensors, experiments on noise, properties of

the light bulb.
Heat: calorimetry, heat transfer, Newton's cooling under ambient and forced convection and radiation, measurement of temperature using Si diodes, thermistors, thermocouples and RTD's, blackbodies, heat pumps and heat engines, investigation of gas laws and laws of thermodynamics, thermal conductivity by pulsed heating of a metal rod, measurement of latent heats and specific heat capacities, temperature control using PID (proportional integral-derivative) schemes, thermal expansivity and its measurement using strain gauges.

Waves and Oscillations, Sound: resonance in a stretched string, normal modes of oscillation, dispersion relations for mono and diatomic lattice, coupled oscillators, nonlinear oscillations exemplified by resistance inductance-diode circuits, magnetic pendulums, accelerometers, measurement of the speed of sound under conditions of varying temperature, solitons, Lorentz pendulum, waves in water, beats, super-positions of harmonic motion (Lissajous patterns), sonometer.
Optics (basic and advanced) and Spectroscopy: Sources of light including bulbs, light emitting diodes, laser diodes and gas lasers, experiments demonstrating optical phenomena such as interference, diffraction, linear motion, reflection, refraction, dispersion, Michelson interferometry, measurement of refractive index using interferometry, measurement of the speed of light, diffraction gratings and multiple-slit interference, thin film interference and Newton's rings, use of digital cameras for optics experiments, mode structure of lasers, use of spectrometers and monochromators, wavelength tuning of laser diodes, rainbows, emission spectroscopy of low-pressure gases (hydrogen), alkali spectra and fine structure, hyperfine structure of rubidium, vibrational spectrum of nitrogen, Lambert-Beer's law, optical polarization, magneto-optical faraday rotation.

Electronics: DC voltages and current measurement, simple DC circuits, generating and analyzing time-varying signals, opamps and comparators, amplifier design, RC transients, filters, frequency response, LC circuits, resonance, transformers, diodes, modulation and radio reception, MOSFET characteristics and applications, principles of amplification, bipolar transistors and amplifiers, digital logic circuits, gates and latches, D-flip flops and shift registers, JK flip-flops and ripple counters.

Modern Physics: photoelectric effect, Frank-Hertz's quantization of energy levels, determination of Planck's constant (e.g. using a light bulb), verification of Moseley's law using X-ray fluorescence, Compton effect, Millikan's experiment for determination of charge of electron, properties of nuclear radiation (absorption in different media and response to external magnetic fields), statistical nature of radioactivity, determination of the half-life of radioisotopes, Giger-Muller tubes, cloud chambers, energy spectroscopy of gamma rays, experiments on medical physics.

Electronic Materials: measurement of electrical conductivity by two-probe and four-probe methods, band gap estimation of intrinsic and extrinsic semiconductors, carrier lifetimes and mobilities, Hall effect and its application in measuring magnetic fields, thermoelectric effects.

Advanced Experiments: nuclear magnetic resonance, electron spin resonance, Zeeman effect, optical pumping, lifetime of muons, surface plasmon resonance, Brownian motion, experiments with vacuum, low temperature physics, superconductivity, synthesis of nanomaterials and their characterization, electromagnetically induced transparency, Mossbauer spectroscopy.

Recommended Books:

1. A. C. Melissinos and J. Napolitano, “Experiments in Modern Physics”, Academic Press, 2nd ed.2003.
2. J. H. Moore, C. C. Davis, M. A. Coplan, and S. C. Greer, "Building Scientific Apparatus", Cambridge University Press, 4th ed. 2009.
3. J. R. Taylor, "An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements", University of Science Books, 2nd ed. 1996.
4. L. Kirkup and R. B. Frenkel, “An Introduction to Uncertainty in Measurement”, Cambridge University Press, 2006.
5. G. L. Squires, "Practical Physics", Cambridge University Press, 4th ed. 2001.
6. Y. Tsividis, "A First Lab in Circuits and Electronics", John Wiley 2001.

Annexure "I"

SCHEME OF STUDIES FOR M.Sc. PHYSICS (2-YEAR) PROGRAM

	Categories	No. of Courses	Credit Hours
M	Major Courses including research project	15-17	45-51
L	Lab courses	3	6
E	Electives	5	15
Total		23-25	66-72

Note: The number of elective courses are 5 (five) for project students and the rest will take 6 (Six) courses

ELIGIBILITY CRITERIA FOR M.SC. PHYSICS (2 YEAR) PROGRAM

- B.Sc. with Physics and Mathematics-A with at least 45% marks in the subject of Physics

SEMESTERWISE BREAKDOWN FOR M.Sc. PHYSICS COURSES

First Year

Semester-I

C. Code	Courses Title	Cr. Hr.	Remarks	PR/CR
PHY 501	Mathematical Methods of Physics-I	3 (3-0)	Maj-1	----
PHY 502	Electrodynamics-1	3 (3-0)	Maj-2	----
PHY 503	Classical Mechanics	3 (3-0)	Maj-3	----
PHY 504	Electronics-1	3 (3-0)	Maj-4	----
PHY 505	Quantum Mechanics-I	3 (3-0)	Comp-9	----
PHY 506L	Lab-I	2 (0-2)	Maj-5	----
	Total Credit Hours	**17**		

Semester-II

C. Code	Courses Title	Cr. Hr.	Remarks	PR/CR
PHY 551	Mathematical Methods of Physics-II	3 (3-0)	Maj-6	PHY-301
PHY 552	Solid State Physics-I	3 (3-0)	Maj-7	PHY-352/PHY-355
PHY 553	Electrodynamics-II	3 (3-0)	Maj-8	PHY-302
PHY 554	Electronics-II	3 (3-0)	Maj-9	PHY-304
PHY 555	Statistical Mechanics	3 (3-0)	Maj-10	----
PHY 556L	Lab-II	2 (0-2)	Maj-11	----
	Total Credit Hours	**17**		

Second Year

Semester-III

C. Code	Courses Title	Cr. Hr.	Remarks	PR/CR
PHY 601	Quantum Mechanics-II	3 (3-0)	Maj-12	PHY-352
PHY 602	Atomic & Molecular Physics	3 (3-0)	Maj-13	PHY-352/ PHY-401
PHY 603	Solid State Physics-II	3 (3-0)	Maj-14	PHY-403
PHY 604	Elective	3 (3-0)	Elective	----
PHY 605	Nuclear Physics	3 (3-0)	Maj-15	PHY-202
PHY 610L	Lab-III	2 (0-2)	Maj-16	----
	Total Credit Hours	**17**		

Semester-IV

C. Code	Courses Title	Cr. Hr.	Remarks	PR/CR
PHY 651	Elective	3 (3-0)	Elective	----
PHY 652	Elective	3 (3-0)	Elective	----
PHY 653	Elective	3 (3-0)	Elective	----
PHY 654	Elective	3 (3-0)	Elective	----
PHY 698	Research Project/Elective Course	3 (3-0)	Maj-17	----
	Total Credit Hours	**15**		

Note: Elective Course in (PHY-499) Means Physics Major Course.

Minimum Degree Credit Hours= 66

Marks Breakdown for M.Sc. Courses

Item	**Maximum Marks**
Mid Term Examination	30%
Internal Marks (Assignments, Quizzes, Presentations)	20%
Final Term Examination	50%
Total	100%

Marks Breakdown for M.Sc. Labs (I-III)

Item	**Maximum Marks**
Lab Report	20%
Practical/Viva	80%
Total	100%

RECOMMENDED CURRICULUM FOR M.Sc. PHYSICS (2 YEAR) PROGRAM

MATHEMATICAL METHODS OF PHYSICS-I

Pre-requisite: **Mechanics, Differential Equations, Linear Algebra**
Credit Hours: **3 (3-0)**
Course Code: **PHY-301**

Objective(s):
To develop the mathematical background of student in vectors, tensors, matrices and some of their uses in the world of physics, to give basic understanding of group theory and complex variables used in physics.
Learning Outcomes:
After Studying this course the students will learn to develop the mathematical background in vectors, tensors, matrices, group theory and some of their uses in the world of Physics.

Week 1: Vector Analysis, Ordinary Derivatives of vector valued functions, Continuity and differentiability
Week 2: Partial derivative of vectors, Differential geometry, Ordinary Integrals of vector valued function
Week 3: Line integrals, surface integrals, Volume Integrals, The Divergence theorem of Gauss, Stoke's theorem
Week 4: Green's theorem in the plane, Transformation of coordinates, Orthogonal Curvilinear Coordinate
Week 5: Unit vectors in curvilinear system, Arc length and volume element, Gradient, divergence and Curl.
Week 6: Special orthogonal coordinate system, Cylindrical coordinates, Spherical coordinate systems.
Week 7: Partial Differential Equations, Introduction to important PDEs in Physics (wave equation, diffusion equation, Poisson's equation, Schrodinger's equation)
Week 8: General form of solution, general and particular solutions (first order, inhomogeneous, second order)
Week 9: characteristics and existence of solutions, uniqueness of solutions, separation of variables
Week 10: Cartesian coordinates, superposition of separated solutions, General Solution
Week 11: Separation of variables in curvilinear coordinates, integral transform methods, Green's functions.
Week 12: Complex Analysis, Review (polar form of complex numbers and de Moivre's theorem, complex logarithms and powers),

Week 13: functions of a complex variable, Cauchy-Riemann conditions, power series in a complex variable and analytic continuation with examples
Week 14: Multi-valued functions and branch cuts, singularities and zeroes of complex functions, complex integration
Week 15: Cauchy's theorem, Cauchy's integral formula, Laurent series and residues
Week 16: Residue integration theorem, definite integrals using contour integration.

Recommended Books:

1. G. Arfken, H. J. Weber, and F. E. Harris, "Mathematical Methods for Physicists", Academic Press, 7th ed. 2012.
2. K. F. Riley, M. P. Hobson, S. J. Bence, "Mathematical Methods for Physicists", Cambridge University Press, 2006.
3. E. Kreyszig, "Advanced Engineering Mathematics", John Wiley, 8th ed. 1999.
6. Vector analysis, by Murray Spiegel. McGraw Hill

ELECTRODYNAMICS-I

Pre-requisites: **Electricity and Magnetism, Calculus-II**
Credit Hours: **3 (3-0)**
Course Code: **PHY-302**

Objective(s):
To understand the basic ideas of electromagnetism and the phenomenon's associated with Electric and Magnetic fields.
Learning Outcomes: After studying this subject, the student will learn to understand the basic ideas of electromagnetism and the phenomenon's associated with Electric and Magnetic fields.

Week 1: Review of Calculus, vector algebra and calculus, Cartesian coordinates spherical coordinates.
Week 2: The Dirac Delta Function, Review of vector calculus using example of Dirac Delta function, the divergence of r/r^2, the one-dimensional and the three dimensional
Week 3: Dirac delta functions. The theory of vector fields, the Helmholtz theorem, potentials.
Electrostatics, The electric field: introduction, Coulomb's law, the electric field, continuous charge distributions.
Week 4: Divergence and curl of electrostatic fields: field lines, flux and Gauss's law, the divergence of E, applications of Gauss's law, the curl of E. Electric potential, introduction to potential, comments on potential
Week 5: Poisson's equation and Laplace's equation, the potential of a localized charge distribution, summary, electrostatics boundary conditions, Work and energy in electrostatics,

Week 6: The work done to move a charge, the energy of a point charge distribution, the energy of a continuous charge distribution, Comments on electrostatic energy. Conductors, basic properties, induced charges, surface charge and the force on a conductor, capacitors.
Week 7: Special Techniques, Laplace's equation: introduction, Laplace's equation in one, two and three dimensions,
Week 8: boundary conditions and uniqueness theorems, conductors and second uniqueness theorems.
Week 9: The Method of Images: The classic image problem, induced surface charge, force and energy, other image problems.
Week 10: Multi-pole Expansion, Approximate potential at large, the monopole and dipole terms, origin of coordinates in multi-pole, expansions, the electric field of a dipole.
Week 11: Electric Fields in Matter, Polarization: dielectrics, induced dipoles, alignment of polar molecules, polarization. The field of a polarized object: bound charges, physical interpretation of bound charges and the field inside a dielectric.
Week 12: The electric displacement: Gauss's law in the presence of dielectrics, a deceptive parallel, boundary conditions. Linear Dielectrics: susceptibility, permittivity, dielectric constant, boundary value problems with linear dielectric energy in dielectric systems
Week 13: Magnetostatics, The Lorentz Force law, magnetic fields, magnetic forces, currents. The Biot-Savart Law: steady currents, the magnetic field of a steady current. The divergence and curl of B: straight-line currents,
Week 14: the divergence and curl of B, applications of Ampere's law, comparison of magnetostatics and electrostatics. Magnetic Vector Potential: the vector potential, summary, magnetic boundary conditions, multi-pole expansion of the vector potential.
Week 15: Magnetic Fields in Matter, Magnetization, diamagnets, paramagnets, ferromagnets, torques and forces on magnetic dipoles, effect of a magnetic field on atomic orbits, magnetization. The Field of a Magnetized Object
Week 16: bound currents, physical interpretation of bound currents, and the magnetic field inside matter. The auxiliary field H: Ampere's law in magnetized materials, a deceptive parallel, boundary conditions. Linear and nonlinear media: magnetic susceptibility and permeability, ferromagnetism.

Recommended Books:

1. D. J. Griffiths, "Introduction to Electrodynamics", Prentice Hall, 3rd ed. 1999.
2. M. N. O. Sadiku, "Elements of Electromagnetics", Oxford University Press, 5th ed. 2009.
3. F. Melia, "Electrodynamics", University of Chicago Press, 2001.
4. Hearld J and W. Muller-Kristen, "Electrodynamics", World Scientific Publishing, 2nd ed. 2011.

CLASSICAL MECHANICS

Pre-requisites: **Mechanics**
Credit Hours: **3 (3-0)**
Course Code: **PHY-303**
Objective(s):
To develop the basic knowledge of classical world using the laws of Physics. The various formulations of classical mechanics will help to develop the understanding of various branches of Physics.
Learning Outcomes: After studying this subject, the student will learn to understand the basic ideas and formulations of Classical Mechanics.

Week 1: Review of Newtonian Mechanics, Frame of reference, orthogonal transformations,
Week 2: Angular velocity and angular acceleration, Newton's laws of motion, Galilean transformation, conservation laws,
Week 3: systems of particles, motion under a constant force, motions under variable force, time-varying mass system.
Week 4: The Lagrange Formulation of Mechanics and Hamilton Dynamics.
Week 5: Generalized co-ordinates and constraints, D'Alembert principle and Lagrange's Equations,
Week 6: Hamilton's principle, integrals of motion, non-conservative system and generalized potential,
Week 7: Lagrange's multiplier method, the Hamiltonian of a dynamical system,
Week 8: Canonical equations, canonical transformations, Poisson brackets, phase space and Liouville's theorem.
Week 9: Central Force Motion, The two-body problem, effective potential and classification of orbits, Kepler's laws,
Week 10: Stability of circular orbits, hyperbolic orbits and Rutherford scattering,
Week 11: Center of mass co-ordinate system, scattering cross-sections.
Week 12: Motion in Non-inertial Systems, Accelerated translational co-ordinate system,
Week 13: Dynamics in rotating co-ordinate system, motion of a particle near the surface of the earth.
Week 14: The Motion of Rigid Bodies, The Euler angles, rotational kinetic energy and angular momentum, the inertia tensor.
Week 15: Euler equations of motion, motion of a torque-free symmetrical top.
Week 16: Stability of rotational motion.

Recommended Books:
1. T. L. Chow, "Classical Mechanics", John Wiley, 1995.
2. T. Kibble and F. Berkshire, "Classical Mechanics", World Scientific, 5th ed. 2004.

ELECTRONICS-I

Pre-requisites: **Modern Physics**
Credit Hours: **3 (3-0)**
Course Code: **PHY-304**

Objective(s):
The main objective of this course is to enable the students to understand the construction operation and modeling of semiconductor devices, and to inculcate in them the ability to analyze and design various electronic circuits.
Learning Outcomes: After studying this subject, the student will learn to understand the construction operation and modeling of semiconductor devices and to inculcate in them the ability to analyze and design various electronic circuits.

Week 1: The Semiconductor Diode: Metals, insulators and semiconductors, Conduction in Silicon and Germanium, The forbidden energy gap, n and p type semiconductors,
Week 2: the junction diode, diode voltage-current equation, Zener diodes, light emitting diodes, photodiodes, capacitance effects in the pn junction.
Week 3: The Diode as Rectifier and Switch, The ideal diode model, the half wave rectifier, the full wave rectifier, the bridge rectifier, measurement of ripple factor in the rectifier circuit,
Week 4: the capacitor filter, the ∏ filter, the ∏-R filter, the voltage doubling rectifier circuit, rectifying AC voltmeters, diode wave clippers, diode clampers.
Week 5: Circuit Theory and Analysis, Superposition theorem, Thevenin's Theorem, Norton's Theorem, Model for circuit, one port and two-port network,
Week 6: Hybrid parameter equivalent circuit, Power in decibels, The Junction Transistor as an Amplifier:
Week 7: Transistor voltage and current designations, the junction transistors, the volt-ampere curve of a transistor, the current amplification factors,
Week 8: the load line and Q point, the basic transistor amplifiers, the common emitter amplifier,
Week 9: the trans-conductance gm, performance of a CE amplifier, relation between Ai and Av, the CB amplifier, the CC amplifier, comparison of amplifier performance.
Week 10: DC Bias for the Transistor, Choice of Q point, variation of Q point, fixed transistor bias,
Week 11: The four-resistor bias circuit, design of a voltage feedback bias circuit, Common emitter, common collector, common base biasing.
Week 12: Field Effect Transistor, What is /field effect transistor, JFET: Static characteristics of JFET,
Week 13: Metal oxide semiconductor Field Effect Transistor (MOSFET of IGFET): enhancement and depletion mode,

Week 14: FET biasing techniques, Common drain, common source and common gate, fixed bias and self-bias configurations, Universal JFET bias curve, Darlington pair.
Week 15: Operational Amplifiers, The integrated amplifier, the differential amplifier, common mode rejection ratio, the operational amplifier.
Week 16: Summing operation, integration operation, comparator, milli-voltmeter.

Recommended Books:

1. Thomas L. Floyd, "Electronics Fundamentals: Circuits, Devices and Applications", Prentice Hall, 8th ed., 2009.
2. Electronic devices and circuit theory, Book by Louis Nashelsky and Robert Boylestad, Latest Edition.
2. B. Grob, "Basic Electronics", McGraw-Hill, Tch ed. 1997.
3. B. Streetman and S. Banerjee "Solid State Electronics Devices", Prentice Hall, 6th ed. 2005.
4. A. Bar-lev, "Semiconductor and Electronics Devices", Prentice Hall, 3rd ed. 1993.
5. D. H. Navon and B. Hilbert, "Semiconductor Micro-devices and Materials", CBS College Publishing, 1986.
6. A. P. Malvino, "Electronic Principles", McGraw-Hill, 7th ed. 2006.
7. R. T. Paynter, "Introductory Electric Circuits", Prentice Hall, 1998.

MATHEMATICAL METHODS OF PHYSICS-II

Pre-requisite:	**Mathematical Methods of Physics-II**
Credit Hours:	**3 (3-0)**
Course Code:	**PHY-351**

Objective(s)
To give the clear understanding of special functions, Fourier series, Fourier Transforms, Legendre functions and other orthogonal functions.
Learning Outcomes: After studying this subject, the student will learn to understand the advanced mathematical tools to solve various problems in advanced Physics and Engineering courses.

Week 1: Fourier series, Fourier series, Dirichlet conditions, Odd and even functions,
Week 2: half range Fourier sine or cosine series, complex notations for Fourier series,
Week 3: Orthogonal functions. The Fourier integral, Equivalent forms of Fourier's integral theorem, Parseval's identities for Fourier integrals.
Week 4: Gamma, Beta and other Special functions, The Gamma function and its graphical representations, Asymptotic formula for gamma function,
Week 5: The Beta function, Dirichlet integrals, Other Special functions, Error function,

Week 6: Exponential integrals, Fresnel sine and cosine integrals, asymptotic series or expansions.
Week 7: Bessel Functions, Bessel differential equation. Bessel functions of the first kind.
Week 8: Miscellaneous Problems
Week 9: Bessel's Functions of the second kind, Generating functions for the Bessel function,
Week 10: Recurrence formulas, Functions related to Bessel's function,
Week 11: Asymptotic formulas for Bessel's functions, Series of Bessel's function.
Week 12: Legendre Function and Other Orthogonal Functions, Legendre's differential equation, Legendre Polynomials.
Week 13: Generating function for Legendre Polynomials, recurrence formulas.
Week 14: Legendre functions of the first kind, Orthogonality of Legendre polynomials,
Week 15: Series expansion of Legendre Polynomials. Associated Legendre Functions. Hermit Polynomials.
Week 16: Miscellaneous Problems

Recommended Books:

1. Arfken G.B and H.J Weber, F.E Harris, 2012, 7th Edition, Mathematical Methods for Physicists, A. Press, New York.

2. Dass H.K, R. Verma, 2011, 6th Edition, Mathematical Physics, S. Chand& Company Ltd. New Delhi.

3. Kreyszig E. 2011, 10th Edition, Advanced Engineering Mathematics. Wiley, New York.

4. Collins R.E, 2011, 2nd Edition, Mathematical Methods for Physicists and Engineers, Dover Publications.

QUANTUM MECHANICS-I

Pre-requisites:	**Modern Physics**
Credit Hours:	**3 (3-0)**
Course Code:	**PHY-352**

Objective(s)
To give the understanding of quantum mechanical solutions to various physical system such as harmonic oscillator etc.
Learning Outcomes: After studying this subject, the student will learn quantum mechanical solutions to various physical system such as harmonic oscillator etc.

Week 1: Waves and Particles: Introduction to the fundamental ideas of quantum mechanics Electromagnetic waves and photon, material particles and matter waves, quantum description of a particle,

Week 2: Wave packets, particle in a time-independent scalar potential, order of magnitude of the wavelength associated with material particles, constraints imposed by uncertainty relations,

Week 3: One-dimensional Gaussian wave packet: Spreading of the wave packet, stationary states of a particle in one-dimensional square potential, behavior of a wave packet at a potential step. The Mathematical Tools of Quantum Mechanics, One-particle wave function space, state space, Dirac notation, representations in the state space, observable,

Week 4: Representations, review of some useful properties of linear operators, unitary operators, study of the and representations, some general properties of two observable, Q and P, whose commutator is equal to iħ, the two-dimensional infinite well.

Week 5: The Postulates of Quantum Mechanics, Statement of the postulates and their physical interpretation, the physical implications of the Schrodinger equation, the superposition principle, particle in an infinite potential well,

Week 6: Study of the probability current in some special case, root-mean-square deviations of two conjugate observables, the density and evolution operators, Schrodinger and Heisenberg pictures, Gauge invariance,

Week 7: Bound states of a particle in a potential well of arbitrary shape, unbound states of a particle in the presence of a potential well or barrier of arbitrary shape, quantum properties of a particle in a one-dimensional periodic structure.

Week 8: Application of The Postulates to Simple Cases, Spin ½ And Two-Level Quantum Systems: Spin ½ particles, quantization of the angular momentum, illustration of the postulates in the case of a spin ½, general study of two level systems,

Week 9: Pauli matrices, diagonalization of a 2×2 Hermitian matrix, System of two spin ½ particles, Spin ½ density matrix, and Spin ½ particles in a static magnetic field and a rotating field, Magnetic resonance.

Week 10: The One-Dimensional Harmonic Oscillator, Importance of the harmonic oscillator in physics, eigenvalues and eigenstates of the Hamiltonian, mean value and root-mean-square deviations of X and P in state | , Some examples of harmonic oscillators,

Week 11: Study of the stationary states in the representation, Hermite polynomials, solving the Eigenvalues of the harmonic oscillators by the polynomial method, study of the stationary states in the representation, isotropic three-dimensional harmonic oscillator, charged harmonic oscillator placed in a uniform electric field, coherent states,

Week 12: Normal vibrational modes of coupled harmonic oscillators, vibrational modes of an infinite linear chain of coupled harmonic oscillators, phonons, one-dimensional harmonic oscillator in thermodynamics equilibrium at a temperature T.

Week 13: General Properties of Angular Momentum in Quantum Mechanics, concept of angular momentum in quantum mechanics, commutation relations, application to orbital angular momentum, spherical harmonics, rotation operators, rotation of diatomic molecules, angular momentum of stationary states of a two-dimensional harmonic oscillator, charged particle in a magnetic field and Landau levels.

Week 14: Particle in a Central Potential, The Hydrogen atom, Stationary states of a particle in a central potential, motion of the center of mass and relative motion for a system of two interacting particles,
Week 15: Hydrogen atom, Hydrogen like systems, A solvable example of a central potential: the isotropic three-dimensional harmonic oscillator, probability currents associated with the stationary states of the hydrogen atom,
Week 16: The hydrogen atom placed in a uniform magnetic field, para-magnetism and diamagnetism, Zeeman effect, study of some atomic orbitals, vibrational-rotational levels of diatomic molecules.

Recommended Books:

4. D.J. Griffiths, "Introduction to Quantum Mechanics", Addison-Wesley, 2nd ed. 2004.R.
5. Liboff, "Introductory Quantum Mechanics", Addison-Wesley, 4 ed. 2002.
6. N. Zettili, "Quantum Mechanics: Concepts and Applications", John Wiley, 2nd ed. 2009.

ELECTRODYNAMICS-II
Pre-requisites: **Electrodynamics-I**
Credit Hours: **3 (3-0)**
Course Code: **PHY-353**
Objective(s)
To understand the basic ideas of electromagnetism and the various phenomenon associated with electric and magnetic field and their propagations.
Learning Outcomes: After studying this subject, the student will learn the basic ideas of electromagnetism and the various phenomenon associated with electric and magnetic field and their propagations

This course is the second part of the core level undergraduate course on Electromagnetic Theory and a previous knowledge of Electromagnetic Theory I is expected.

Week1: Electrodynamics, Electromotive force: Ohm's law, electromotive force and motional emf, electromagnetic induction: Faraday's law, the induced electric field, inductance,
Week 2: Energy in magnetic fields, Maxwell's equations: electrodynamics before Maxwell, how Maxwell fixed Ampere's law,
Week 3: Maxwell's equations, magnetic charges, Maxwell's equations in matter, boundary conditions.
Week 4: Conservation Laws, Charge and energy: the continuity equation, Poynting's theorem, momentum: Newton's third law in electrodynamics,
Week 5: Maxwell's stress tensor, conservation of momentum, angular momentum.

Week 6: Electromagnetic Waves, Waves in one dimension: the wave equation, sinusoidal waves, boundary conditions, reflection and transmission, polarization,
Week 7: electromagnetic waves in vacuum: the wave equation for E and B, monochromatic plane waves, energy and momentum in electromagnetic waves, electromagnetic waves in matter: propagation in linear media, reflection and transmission at normal incidence,
Week 8: Reflection and transmission at oblique incidence, absorption and dispersion: electromagnetic waves in conductors, reflection at a conducting surface,
Week9: The frequency dependence of permittivity, guided waves: wave guides, The waves in a rectangular wave guide, the coaxial transmission line.
Week 10: Potentials and Fields, The potential formulation: scalar and vector potentials, gauge transformations, Coulomb gauge and Lorentz gauge,
Week 11: Continuous distributions: retarded potentials, Jefimenko's equations, point charges: Lienard-Wiechert potentials, the field of a moving point charge.
Week 12: Radiation, Dipole Radiation, what is radiation, electric dipole radiation, magnetic dipole radiation, radiation from an arbitrary source, point charges:
Week 13: Power radiated by a point charge, radiation reaction, the physical basis of the radiation reaction. Electrodynamics and Relativity, The special theory of relativity.
Week 14: Einstein's postulates, the geometry of relativity, the Lorentz transformations, the structure of space-time, relativistic mechanics: proper time and proper velocity,
Week 15: Relativistic energy and momentum, relativistic kinematics, relativistic dynamics, relativistic electrodynamics: magnetism as a relativistic phenomenon,
Week 16: How the field transform, the field tensor, electrodynamics in tensor notation, relativistic potentials.

Recommended Books

5. D. J. Griffiths, "Introduction to Electrodynamics", ed. Prentice Hall, 3rd ed. 1999.
6. M. N. O. Sadiku, "Elements of Electromagnetics", Oxford University Press, 5th ed. ed. 2009.
7. F. Melia, "Electrodynamics", University of Chicago Press, 1st ed. 2001.
8. Hearld J and W. Muller-Kristen, "Electrodynamics", World Scientific Publishing, 2nd ed. 2011.

ELECTRONICS-II

Pre-requisites: **Electronics-I**
Credit Hours: **3 (3-0)**
Course Code: **PHY-354**
Objective(s)

The main objective of this course is to inculcate in students the ability to analyze and design basic analog electronic circuits that will be used as building blocks in the design of larger systems.

Learning Outcomes: After studying this subject, the student will learn to analyze and design basic analog electronic circuits that will be used as building blocks in the design of larger systems.

Week 1: Amplifiers and their Frequency Response, Cascade amplifier, The Amplifier pass band, the frequency plot, Low frequency plot, Low frequency limit.

Week 2: The un-bypassed emitter resistor, high frequency equivalent circuit, The Miller Effect, high frequency limit of transistor, bandwidth of a cascade amplifier.

Week 3: Feedback, Positive and Negative feedback, Principle of feedback amplifier, stabilization of gain by negative feedback, Bandwidth improvement with negative feedback,

Week 4: Reduction of nonlinear distortion, control of amplifier output and input resistance, current series feedback circuit, voltage shunt feedback circuit.

Week 5: Oscillators, Introduction, Classification of oscillators, Damped and undamped oscillators, the oscillatory circuit, frequency stability of an oscillator,

Week 6: Essentials of a feedback LC oscillator, tuned base oscillator, Hartley oscillator, Colpitis oscillator, crystal oscillator.

Week 7: Power Amplifiers, Introduction, Power relation in class-A amplifiers, effect of thermal environment, determination of the output distortion, class-B amplifier, efficiency of class-A and class-B amplifiers.

Week 8: Modulation and Demodulation, Introduction, carrier wave modulation, Need for modulation, radio Broadcasting, Methods of modulation, amplitude modulation,

Week 9: Forms of amplitude modulation, single side band system of modulation, Diode for linear detector for amplitude modulation, High power level amplitude modulation, automatic volume control, Frequency modulation.

Week 10: Multivibrators, Multivibrators, Basic types of Multivibrators, uses of Multivibrators, Actable Multivibrators, Mono-stable Multivibrators, Bi-stable Multivibrators, Schmitt Trigger Circuit.

Week 11: Integrated Circuits, Introduction, Integrated circuit advantages and drawbacks, scale of integration, classification of integrated circuit by structure,

Week 12: Classification of integrated circuit by function, comparison between different integrated circuit. Integrated circuit terminology, Integrated circuit fabrication,

Week 13: Basic processing steps. Silicon device processes Silicon wafer preparation, diffusion, Oxidation photolithography, Chemical vapor deposition,

Week 14: Metallization, Circuit probing, Scribing and separating into chips, Mounting and packing applications of integrated circuits.

Week 15: Digital Circuits, Decimal, Binary, Octal, hexadecimal number systems, conversion of decimal numbers to any other number system and vice-versa,

Week 16: Binary codes, OR, AND, NOT, NAND, NOR logic gates, Boolean algebra. Boolean expressions, simplification of Boolean expression using Boolean Algebra.

Recommended Books:

1. Thomas L. Floyd, “Electronics Fundamentals: Circuits, Devices and Applications”, Prentice Hall, 8th ed. 2009.
2. B. Grob, “Basic Electronics”, McGraw-Hill, Tch ed. 1997.
3. B. Streetman and S. Banerjee “Solid State Electronics Devices”, Prentice Hall, 6th ed. 2005.
4. A. Bar-lev, “Semiconductor and Electronics Devices”, Prentice Hall, 3rd ed. 1993.
5. D. H. Navon and B. Hilbert, “Semiconductor Micro-devices and Materials”, CBS College Publishing, 1986.
6. A. P. Malvino, “Electronic Principles”, McGraw-Hill, 7th ed. 2006.
7. R. T. Paynter, “Introductory Electric Circuits”, Prentice Hall, 1998.

STATISTICAL MECHANICS

Pre-requisites:	**Heat and Thermodynamics, Calculus-II, Statistics-I**
Credit Hours:	**3 (3-0)**
Course Code:	**PHY-355**

Objective(s)

The objective of this course is to approach the thermodynamics properties of a system from the statistical point of view. Students will be taught to address problems of systems consisting of large number of particles by studying their collective behavior.

Learning Outcomes: After studying this subject, the student will learn the thermodynamics properties of a system from the statistical point of view. Students will be able to address problems of systems consisting of large number of particles by studying their collective Behaviour

Week 1: Review of Classical Thermodynamics, States, macroscopic vs. microscopic, "heat" and "work", energy,

Week 2: Entropy, equilibrium, laws of thermodynamics, Equations of state,

Week 3: Thermodynamic potentials, temperature, pressure, chemical potential, thermodynamic processes (engines, refrigerators), Maxwell relations, phase equilibria.

Week 4: Foundation of Statistical Mechanics, Phase Space, Trajectories in Phase Space, Conserved Quantities and Accessible Phase Space,

Week 5: Macroscopic Measurements and Time Averages, Ensembles and Averages over Phase Space, Liouville's Theorem, The Ergodic Hypothesis, Equal a priori Probabilities. Specification of the state of a system,

Week 6: Concept of ensembles, elementary probability calculations, distribution functions, statistical interpretation of entropy (Boltzmann theorem).

Week 7: Statistical Ensembles, Micro canonical ensemble, canonical ensemble and examples (e.g., paramagnet)

Week 8: Calculation of mean values, calculation of partition function and its relation with thermodynamic quantities,
Week 9: The grand canonical ensemble and examples (e.g. adsorption), calculation of partition function and thermodynamic quantities.
Week 10: Simple Applications of Ensemble Theory, Monoatomic ideal gas in classical and quantum limit,
Week 11: Gibb's paradox and quantum mechanical enumeration of states, equipartition theorem and examples (ideal gas, harmonic oscillator),
Week 12: Specific heat of solids, quantum mechanical calculation of para-magnetism.
Week 13: Quantum Statistics, In-distinguishability and symmetry requirements, Maxwell-Boltzmann statistics, Bose-Einstein and photon statistics,
Week 14: Fermi Dirac statistics (distribution functions, partition functions). Examples: polyatomic ideal gas (MB), black body radiation (photon statistics),
Week 15: Conduction electrons in metals (FD), Bose condensation (BE). Systems of Interacting Particles: Lattice vibrations in solids,
Week 16: Van der Waals gas, mean field calculation, ferromagnets in mean field approximation.

Recommended Books:

1. F. Reif, "Fundamentals of Statistical and Thermal Physics", Waveland Pr Inc, 2008.
2. W. Brewer, F. Schwabl, "Statistical Mechanics", Springer, 2nd ed. 2006.
3. T. L. Hill, "Statistical Mechanics", World Scientific Publishing Company, (2004).
4. K. Huang, "Statistical Mechanics", John Wiley, 2nd ed. 1987.

QUANTUM MECHANICS-II

Pre-requisites: **Quantum Mechanics-I**
Credit Hours: **3 (3-0)**
Course Code: **PHY-401**

Objective(s)
The objective of this course is to study quantum systems using advanced mathematical techniques, in particular the students will learn how to do quantum mechanics rather than what quantum mechanics means.
Learning Outcomes: After studying this subject, the student will learn to apply advanced quantum mechanical techniques is solving various problems in advanced physics courses.

Week 1: Addition of Angular Momenta, Total angular momentum in classical mechanics, total angular momentum in quantum mechanics,
Week 2: Addition of two spin ½ angular momenta, addition of two arbitrary angular momenta, Clebsch-Gordon coefficients, addition of spherical harmonics,

Week 3: Vector operators, Wigner-Eckart theorem, electric Multi-pole moments, Evolution of two angular momenta J1 and J2 coupled by an interaction a J1 . J2.
Week 4: Stationary Perturbation Theory, Description of the method, perturbation of a non-degenerate level, perturbation of a degenerate level,
Week 5: One-dimensional harmonic oscillator subjected to a perturbing potential, interaction between the magnetic dipoles of two spin ½ particles, Van der waals forces,
Week 6: Volume effect and the influence of the spatial extension of the nucleus on the atomic levels, variational method, energy bands of electrons in solids,
Week 7: A simple example of the chemical bond: The ion Applications of Perturbation Theory to Atomic Systems: fine and hyperfine structure of atomic levels in hydrogen,
Week 8: Calculation of the mean values of the spin-orbit coupling in the 1s, 2s and 2p levels, hyperfine structure And the Zeeman effect for muonium and positronium, Stark effect.
Week 9: Approximation Methods for Time-Dependent Problems, Statement of the problem, approximate solution of the Schrodinger equation,
Week 10: An important special case, Sinusoidal or constant perturbation, Interaction of an atom with electromagnetic waves, linear and non-linear response of a two-level system subjected to a sinusoidal perturbation,
Week 11: Oscillations of a system between two discrete states under the effect of a resonant perturbation, Rabi flopping, decay of discrete state resonantly coupled to a continuum of final states, Fermi's golden rule.
Week 12: Systems of Identical Particles, Identical particles, Permutation operators, the summarization postulate, difference between bosons and fermions,
Week 13: Pauli’s exclusion principle, many-electrons atom and their electronic configurations, energy levels of the helium atom,
Week 14: Configurations terms, multiplets, spin isomers of hydrogen (ortho and para hydrogen).
Week 15: Scattering by a Potential, Importance of collision phenomena, Stationary scattering states, scattering cross section, scattering by a central potential.
Week 16: Method of partial waves, phenomenological description of collisions with absorption.

Recommended Books:

1. D.J. Griffiths, "Introduction to Quantum Mechanics", Addison-Wesley, 2nd ed. 2004.
2. R. Liboff, "Introductory Quantum Mechanics", Addison-Wesley, 4th ed. 2002.
3. N. Zettili, "Quantum Mechanics: Concepts and Applications", John Wiley, 2nd ed. 2009.

ATOMIC AND MOLECULAR PHYSICS

Pre-requisites:	**Quantum Mechanics-I**
Co-requisite:	**Quantum Mechanics-II**
Credit Hours:	**3 (3-0)**

Course Code: **PHY-402**

Objective(s):
To provide an introduction to the structure and spectra of atoms and molecules. To prepare students for more advanced courses on Physics of Atoms, Molecules and Photons.
Learning Outcomes: After studying this subject, the student will learn the structure and spectra of atoms and molecules. The students will be able to apply techniques to more advanced courses on Physics of Atoms, Molecules and Photons.

Week 1: One Electron Atoms, Review of Bohr Model of Hydrogen Atom,
Week 2: Reduced Mass, Atomic Units and Wavenumbers, Energy Levels and Spectra, Schrodinger Equation for One-Electron Atoms,
Week 3: Quantum Angular Momentum and Spherical Harmonics, Electron Spin, Spin-Orbit interaction. Levels and Spectroscopic Notation, Lamb Shift,
Week 4: Hyperfine Structure and Isotopic Shifts. Rydberg Atoms.
Week 5: Interaction of One-Electron Atoms with Electromagnetic Radiation, Radiative Transition Rates, Dipole Approximation, Einstein Coefficients, Selection Rules,
Week 6: Dipole Allowed and Forbidden Transitions. Metastable Levels, Line Intensities and Lifetimes of Excited States,
Week 7: Shape and Width of Spectral Lines, Scattering of Radiation by Atomic Systems, Zeeman Effect, Linear and Quadratic Stark Effect.
Week 8: Many-Electron Atoms, Schrodinger Equation for Two-Electron Atoms, Para and Ortho States, Pauli's Principle and Periodic Table,
Week 9: Coupling of Angular Momenta, L-S and J-J Coupling. Ground State and Excited States of Multi Electron Atoms, Configurations and Terms.
Week 10: Molecular Structure and Spectra, Structure of Molecules, Covalent and Ionic Bonds, Electronic Structure of Diatomic Molecules,
Week 11: Rotation and Vibration of Diatomic Molecules, Born-Oppenheimer Approximation.
Week 12: Electronic Spectra, Transition Probabilities and Selection Rules,
Week 13: Frank Condon Principle, H2+ and H2. Effects of Symmetry and Exchange. Bonding and Anti-bonding Orbitals.
Week 14: Electronic Spin and Hund's Cases, Nuclear Motion:
Week 15: Rotation and Vibrational Spectra (Rigid Rotation, Harmonic Vibrations). Selection Rules.
Week 16: Spectra of Triatomic and Polyatomic molecules, Raman Spectroscopy.
Recommended Books:

1. C. J. Foot, "Atomic Physics", Oxford University Press, 2005.
2. B. H. Bransden and C. J. Joachain, "Physics of Atoms and Molecules", Pearson Education, 2nd ed. 2008.
3. W. Demtroder, "Atoms, Molecules and Photons", y, Springer, 2nd ed. 2010.
4. C. N. Banwell and E. M. McCash, "Fundamentals of Molecular Spectroscopy", McGraw-Hill,

4th ed. 1994.
5. J. M. Hollas, "Basic Atomic & Molecular Spectroscopy", John Wiley, 2002.

SOLID STATE PHYSICS-I

Pre-requisites: **Quantum Mechanics I, Statistical Mechanics**
Credit Hours: **3 (3-0)**
Course Code: **PHY-403**
Objective(s):
The objective of this course is to provide students the basic physical concepts and mathematical tools which are used to describe solid.
Learning Outcomes: After studying this subject, the student will learn the basic physical concepts and mathematical tools which are used to describe solid.

Week 1: Crystal Structure Lattices and basis, Symmetry operations,
Week 2: Fundamental Types of Lattice, Position and Orientation of Planes in Crystals, Simple crystal structures.
Week 3: Crystal Diffraction and Reciprocal Lattice, Diffraction of X-rays, Neutrons and electrons from crystals; Bragg's law;
Week 4: Reciprocal lattice, Ewald construction and Brillouin zone, Fourier Analysis of the Basis.
Week 5: Phonons and Lattice, Quantization of Lattice Vibrations,
Week 6: Phonon momentum, inelastic scattering by phonons,
Week 7: Lattice Vibrations for Monoatomic and diatomic basis, Optical Properties in the Infrared region.
Week 8: Thermal Properties of Solids, Lattice heat Capacity, Classical model,
Week 9: Einstein Model, Enumeration of normal modes, Density of state in one, two or three dimensions, Debye model of heat capacity,
Week 10: Comparison with experimental results, thermal conductivity and resistivity, Umklapp processes.
Week 11: Electrical Properties of Metals, Classical free electron theory of metals,
Week 12: Energy levels and density of orbital's in one dimension,
Week 13: Effect of temperature on the Fermi–Dirac distribution function, properties of the free electron gas,
Week 14: Electrical conductivity and Ohm's Law, thermal and electrical conductivities of metals and their ratio,
Week 15: Motion of free electrons in magnetic fields, cyclotron frequency,
Week 16: Static magneto conductivity and Hall Effect along with applications.

Recommended Books:

1. C. Kittle, "Introduction to Solid State Physics", John Wiley, 8th ed. 2005.
2. N. W. Ashcroft and N. D. Mermin, "Solid State Physics", Rinehart & Winston, 1976.
3. S. R. Elliott, "The Physics and Chemistry of Solids", John Wiley, 1998
4. M. A. Omar, "Elementary and Solid State Physics", Pearson Education, 2000.
5. H. M. Rosenberg, "The Solid State", Oxford Science Publication, 3rd ed. 1988.
6. M. A. Wahab, "Solid State Physics", Narosa Publishing House, 1999.

SOLID STATE PHYSICS -II

Pre-requisites: **Solid State Physics-I**
Credit Hours: **3 (3-0)**
Course Code: **PHY-451**
Objective(s):
The objective of this course is to understand the transport properties in solids, Dielectric and magnetic properties of materials and superconductivity.
Learning Outcomes: After studying this subject, the student will learn the transport properties in solids, Dielectric and magnetic properties of materials and superconductivity.

Week 1: Dielectric Properties of Solids, Polarization, Depolarization, Local and Maxwell field, Lorentz field, Clausius-Mossotti relation
Week 2: Dielectric Constant and Polarizability, Measurement of dielectric constant, ferro electricity and ferroelectric crystals, Phase Transitions,
Week 3: First and 2nd order phase transitions, Applications
Week 4: Semiconductors: General properties of semiconductors, intrinsic and extrinsic semiconductors, their band structure,
Week 5: Carrier statistics in thermal equilibrium, band level treatment of conduction in semiconductors and junction diodes, diffusion and drift currents,
Week 6: Collisions and recombination times.
Week 7: Optical Properties, Interaction of light with solids, Optical Properties of Metals and Non-Metals, Kramers Kronnig Relation, Excitons,
Week 8: Raman Effect in crystals, optical spectroscopy of solids.
Week 9: Magnetic Properties of Materials**:** Magnetic dipole moment and susceptibility, different kinds of magnetic materials,
Week 10: Langevin diamagnetic equation, Paramagnetic equation and Curie law, Classical and quantum approaches to paramagnetic materials.
Week 11: Ferro-magnetic and anti – ferromagnetic order, Curie point and exchange integral,
Week 12: Effect of temperature on different kinds of magnetic materials and applications.
Week 13: Superconductivity, Introduction to superconductivity,

Week 14: Zero-Resistance and Meissner Effect , Type I and Type II superconductors, Thermodynamic fields,
Week 15: Tow fluid model, London equations , BCS and Ginzburg Landau Theory,
Week 16: Vortex behavior, Critical Current Density, Josephson effect and applications.

Recommended Books:

1. C. Kittle, "Introduction to Solid State Physics", John Wiley, 8th ed. 2005.
2. N. W. Ashcroft and N. D. Mermin, "Solid State Physics", Rinehart & Winston, 1976.
3. G. Burns, "High Temperature Superconductivity: An Introduction", Academic Press, 1992.
4. M. Fox, "Optical Properties of Solids", Oxford University Press, 2nd ed. 2010.
5. N. A. Spaldin, "Magnetic Materials: Fundamentals and Device Applications", Cambridge University Press, 2nd ed. 2010.

NUCLEAR PHYSICS

Pre-Requisites: **Modern Physics**
Credit Hours: **3 (3-0)**
Course Code: **PHY-404**

Objective(s):
To understand the nuclear structure using different nuclear models. To understand the nature of nuclear forces. To give understanding of radioactivity and nuclear reactions.
Learning Outcomes: After studying this subject, the student will learn the nuclear structure using different nuclear models. The students will be able to understand the nature of nuclear forces radioactivity and nuclear reactions.

Week 1: Introduction to Nuclear Physics Starting from Becquerel's discovery of radioactivity to Chadwick's neutron.
Week 2: Basic Properties of Nucleus
Week 3: Nuclear size, mass, binding energy, nuclear spin,
Week 4: Magnetic dipole and electric quadrupole moment, parity and statistics.
Week 5: Nuclear Forces Yukawa's theory of nuclear forces.
Week 6: Nucleon scattering, charge independence and spin dependence of nuclear force, isotopic spin.
Week 7: Nuclear Models Liquid drop model, Fermi gas model, Shell model,
Week 8: Collective model Theories of Radioactive Decay: Theory of Alpha decay and explanation of observed phenomena,
Week 9: Measurement of Beta ray energies, the magnetic lens spectrometer,
Week 10: Fermi theory of Beta decay, Neutrino hypothesis, theory of Gamma decay,

Week 11: Multipolarity of Gamma rays, nuclear isomerism, Nuclear Reactions Conservation laws of nuclear reactions,
Week 12: Q-value and threshold energy of nuclear reaction, energy level and level width
Week 13: Cross sections for nuclear reactions,
Week 14: compound nucleolus theory of nuclear reaction and its limitations,
Week 15: Direct reaction, resonance reactions,
Week 16: Breit-Wigner one level formula including the effect of angular momentum.

Recommended Books:

1. E. Segre, "Nuclei and Particles", Bejamin-Cummings, 2nd ed. 1977.
2. Kaplan, "Nuclear Physics", Addison-Wisely, 1980.
3. Green, "Nuclear Physics", McGraw-Hill, 1995.
4. K. S. Krane, "Introducing Nuclear Physics", John Wiley, 3rd ed. 1988.
5. B. Povh, K. Rith, C. Scholtz, F. Zetsche, "Particle and Nuclei", 1999.

Annexure "K"

DETAIL OF ELECTIVE COURSES FOR M.Sc. PHYHSICS (2 YEAR) PROGRAM

The elective courses can be chosen from the list according to the availability of expert teachers.

List of Elective courses M.Sc. Physics Programme

	Subjects	Cr. Hr	C. Code	PR/CR (BS-Physics)	PR/CR (M.Sc. Physics)
20.	Plasma Physics	3(3-0)	PHY-411	PHY-201, PHY-353	PHY-353
21.	Electronic Materials and Devices	3(3-0)	PHY-461	PHY-251, PHY-304	PHY-304
22.	Materials Science	3(3-0)	PHY-462	PHY-403	PHY-403
23.	Nano Science and Nanotechnologies	3(3-0)	PHY-463	PHY-451, PHY-401	PHY-451, PHY-401
24.	Digital Electronics	3(3-0)	PHY-464	PHY-354	PHY-354
25.	Methods of Experimental Physics	3(3-0)	PHY-465	----	----
26.	Environmental Physics	3(3-0)	PHY-466	----	----
27.	Introduction to Quantum Computing	3(3-0)	PHY-467	PHY-352, PHY-477	PHY-352, PHY-477
28.	Quantum Information Theory	3(3-0)	PHY-468	PHY-352	PHY-352
29.	Quantum Field Theory	3(3-0)	PHY-469	PHY-401	PHY-401
30.	Lasers	3(3-0)	PHY-470	PHY-401, PHY-402	PHY-401, PHY-402
31.	Experimental Techniques in Particle and Nuclear Physics	3(3-0)	PHY-471	PHY-474, PHY-404	PHY-474, PHY-404
32.	Fluid Dynamics	3(3-0)	PHY-472	PHY-101, Calculus-I, ODEs	
33.	Introduction to Photonics	3(3-0)	PHY-473	PHY-201, PHY-251, Linear algebra, PHY-304	PHY-304

34.	Particle Physics	3(3-0)	PHY-474	PHY-401, PHY-404	PHY-401, PHY-404
35.	Computer Simulations in Physics	3(3-0)	PHY-475	Calculus-II, Linear algebra, Statistics-I, ODEs, PHY-101, Into. to Computing	----
36.	Surface Sciences	3(3-0)	PHY-476	PHY-451	PHY-451
37.	Computational Physics	3(3-0)	PHY-477	----	----
38.	Clay Science	3(3-0)	PHY-478	PHY-403	PHY-403

PLASMA PHYSICS

Pre-requisite: **Electromagnetic Theory-II, Waves and Oscillations**
Credit Hours: **3 (3-0)**
Course Code: **PHY-411**

Objective(s):
To learn about the importance of the plasma along with the basic concept of plasma. To know fluid description of the plasma.

Learning Outcomes:
After studying this course the students will learn the importance of the plasma along with the basic concept of plasma. And to know fluid description of the plasma.

Week 1: Introduction to Basic Concepts
Week 2: Occurrence of plasma
Week 3: Concept of temperature, Debye shielding
Week 4: The plasma parameter, Criteria for plasma.
Week 5: Applications of Plasma Physics
Week 6: Single-particle motion in electromagnetic field
Week 7: Uniform and non-uniform E and B fields
Week 8: Time-variant E and B fields
Week 9: Fluid description of plasma
Week 10: Wave propagation in plasma
Week 11: Derivation of dispersion relations for simple electrostatic and electromagnetic modes
Week 12: Introduction to Controlled Fusion

Week 13: Basic nuclear fusion reactions
Week 14: Reaction rates and power density
Week 15: Radiation losses from plasma
Week 16: Operational conditions

Recommended Books:

1. F. F. Chen, "Introduction to Plasma Physics", 2nd ed. Plenum, 1995.
2. D. A. Gurnett and A. Bhattacharjee, "Introduction to Plasma Physics: with space and laboratory application", Cambridge University Press, 2005.
3. T. J. M. Boyd and J. J. Sanderson, "The Physics of Plasmas", Cambridge University Press, 2003.

ELECTRONIC MATERIALS AND DEVICES

Pre-requisite:	**Electronics-I, Optics**
Credit Hours:	**3 (3-0)**
Course Code:	**PHY-461**

Objective(s):
To understand the relation between electrical, optical and magnetic devices.

Learning Outcomes:
After studying this course the students will learn to understand the relation between electrical, optical and magnetic devices.

Week 1: Semiconductor Fundamentals, Composition, purity and structure of semiconductors, energy band model
Week 2: Band gap and materials classification, charge, effective mass and carrier numbers, density of states
Week 3: The Fermi function and equilibrium distribution of carriers, doping, n and p-type semiconductors and calculations involving carrier concentrations, EF etc.,
Week 4: Temperature dependence of carrier concentrations, drift current, mobility, resistivity and band bending
Week 5: Diffusion and total currents, diffusion coefficients, recombination-generation, minority carrier lie times and continuity equations with problem solving examples.
Week 6: Device Fabrication Processes: Oxidation, diffusion, ion implantation, lithography
Week 7: Thin-film deposition techniques like evaporation, sputtering, chemical vapour deposition (CVD), epitaxy etc.
Week 8: PN Junction and Bipolar Junction Transistor: Junction terminology, Poisson's equation,
Week 9: Qualitative solution, the depletion approximation, quantitative electrostatic relationships, Ideal diode equation, non-idealities
Week 10: BJT fundamentals, Junction field effect transistor, MOS fundamentals.

Week 11: Dielectric Materials: Polarization mechanisms, dielectric constant and dielectric loss, capacitor dielectric materials

Week 12: piezoelectricity, Ferro electricity and pyro electricity.

Week 13: Optoelectronic Devices: Photoconductors, photovoltaics and photodetectors, photodiodes and photovoltaics

Week 14: solar cell basics, LEDs, Lasers, displays, LCDs.

Week 15: Magnetism and Magnetic Materials: Basics of magnetism, hysteresis loops, magnetic domains and anisotropy

Week 16: Hard and soft magnetic materials, transformers, DC motors and data storage.

Recommended Books:

1. R. F. Pierret, "Semiconductor Device Fundamentals", Addison Wesley, 2nd ed. 1996.
2. N. Braithwaite, and G. Weaver, "Electronic Materials", MA: Butterworth, 2nd ed. 1990.
3. S. O. Kasap, "Electronic Materials and Devices", McGraw-Hill, 3rd ed. 2005.
4. R. C. O'Handley, "Modern Magnetic Materials: Principles and Applications", Wiley Inter-Science, 1999.
5. D. Jiles, "Introduction to Magnetism and Magnetic Materials", Chapman & Hall, 2nd ed. 1998.

INTRODUCTION TO MATERIALS SCIENCE

Pre-requisites: **Solid State Physics-I**
Credit Hours: **3 (3-0)**
Course Code: **PHY-462**

Objective(s):

To understand the important aspects of materials. Moving towards microstructures.

Learning Outcomes:

After studying this course the students will learn to understand the important aspects of materials. Moving towards microstructures.

Week 1: Imperfections in Solids: Vacancies, impurities, dislocations

Week 2: Interfacial defects, bulk or volume defects, atomic vibrations

Week 3: Microstructure: Microstructure and microscopy, pressure vs. temperature phase diagrams, temperature vs. composition phase diagrams

Week 4: Equilibrium, thermodynamic functions, variation of Gibbs energy with temperature and composition, general features of equilibrium phase diagrams

Week 5: Solidification, diffusion mechanisms, nucleation of a new phase, phase diagrams of Fe-C system and other important alloys, materials fabrication

Week 6: Mechanical Behavior of Materials: Normal stress and normal strain, shear stress and shear strain, elastic deformation, plastic deformation, Young's modulus, shear modulus

Week 7: Poisson's ratio, elastic strain energy, thermal expansion, estimate of the yield stress, dislocations and motion of dislocations
Week 8: Slip systems, dislocations and strengthening mechanisms
Week 9: Fracture mechanics, ductile fracture, brittle fracture, Griffith criterion, ductile fracture,
Week 10: Toughness of engineering materials, the ductile-brittle transition temperature, cyclic stresses and fatigue, creep.
Week 11: Polymers: Polymer basics, polymer identification, polymer molecules, additional polymerization
Week 12: step growth polymerization, measurement of molecular weight, thermosetting polymers and gels, rubbers and rubber elasticity
Week 13: Configuration and conformation of polymers, the glassy state and glass transition, determination of Tg
Week 14: Effect of temperature and time, mechanical properties of polymers, case studies in polymer selection and processing
Week 15: Biomaterials: Introduction to biomaterials, materials selection, biopolymers
Week 16: Structural polysaccharide hard materials biomaterials.

Recommended Books:

1. W. D. Callister, "Materials Science and Engineering: An Introduction", Wiley, 7th ed. 2006.
2. W. D. Callister and D. G. Rethwisch "Fundamentals of Materials Science and Engineering: An Integrated Approach", Wiley, 4th ed. 2012.
3. J. F. Shackelford, "Introduction to Materials Science for Engineers", Prentice Hall, 7th ed. 2008.
4. http://www.msm.cam.ac.uk/teaching/index.php,
5. http://www.doitpoms.ac.uk/

INTRODUCTION TO NANO SCIENCE AND NANOTECHNOLOGIES

Pre-requisite: **Solid State Physics-II, Quantum Mechanics-II**
Credit Hours: **3 (3-0)**
Course Code: **PHY-463**

Objective(s):

Introduce the concept and applications of nano sciences and nanotechnologies. Nano structures and nano technologies.

Learning Outcomes:

After studying this course the students will learn the concept and applications of nano sciences nanotechnologies and Nano structures.

Week 1: Introduction: Feynman talks on small structures, Nano scale dimension, Course goals and objectives.
Week 2: Quantum Effects: Wave particle duality, Energy quanta, Uncertainty principle, De Broglie relation, Quantum Dots, Moore's law, tunneling.

Week 3: Surfaces and Interfaces: Interfaces, Surface chemistry and physics, Surface modification and characterization
Week 4: Thin Films, Sputtering, Self-assembled films
Week 5: Material Properties: Subatomic physics to chemical systems, types of chemical bonds, solid state Physics, materials and properties.
Week 6: Tools and Instrumentation: STM, AFM, Electron Microscopy, Fluorescence methods, synchrotron radiation.
Week 7: Fabricating Nano Structures: Lithography (photo and electron beam), MBE, Self-assembled masked, FIB, Stamp technology, Nano junctions.
Week 8: Electrons in Nano Structures: Variation in electronic properties, free electron model
Week 9: Bloch's theorem, Band structure, Single electron transistor, Resonant tunneling.
Week 10: Molecular Electronics: Lewis structures, Approach to calculate Molecular orbitals, Donor Acceptor properties
Week 11: Electron transfer between molecules, Charge transport in weakly interacting molecular solids, Single molecule electronics.
Week 12: Nano Materials: Quantum dots, nano wires, nano photonics
Week 13: Magnetic nano structures, nano thermal devices, Nano fluidic devices, biomimetic materials.
Week 14: Nano Biotechnology: DNA micro-arrays, Protein and DNA Assembly
Week 15: Digital cells, genetic circuits, DNA computing.
Week 16: Nanotechnology the Road Ahead: Nanostructure innovation, Quantum Informatics, Energy solutions.

Recommended Books:

1. S. Lindsay, “Introduction to Nanoscience”, Oxford University Press, 2009.
2. C. Binns, “Introduction to Nanoscience and Nanotechnology (Wiley Survival Guides in Engineering and Science)”, Wiley, 2010.

DIGITAL ELECTRONICS

Pre-requisites: **Electronics-II**
Credit Hours: **3 (3-0)**
Course Code: **PHY-464**

Objective(s):

To learn the basics of digital electronics such as Boolean Algebra. To develop logic circuit using the Boolean Algebra. To understand the computer interface and micro-controller along with the embedded systems.

Learning Outcomes:

After studying this course the students will learn the basics of digital electronics such as Boolean

Algebra. And to develop logic circuit using the Boolean Algebra, understanding the computer interface and micro-controller along with the embedded systems.

Week 1: Review of Number Systems: Binary, Octal and Hexadecimal number system, their inter-conversion
Week 2: Concepts of logic, truth table, basic logic gates
Week 3: Boolean algebra: De Morgan's theorem, simplification of Boolean expression by Boolean Postulates and theorem, K-maps and their uses. Don't care condition
Week 4: Different codes. (BCD, ASCII, Gray etc.). Parity in Codes
Week 5: IC Logic Families: Basic characteristics of a logic family. (Fan in/out, Propagation delay time, dissipation, noise margins etc.
Week 6: Different logic based IC families (DTL, RTL, ECL, TTL, CMOS)
Week 7: Combinational Logic Circuit: Logic circuits based on AND – OR, OR-AND, NAND, NOR Logic
Week 8: Gate design, addition, subtraction (2's compliments, half adder, full adder, half subtractor, full subtractor encoder, decoder, PLA. Exclusive OR gate
Week 9: Sequential Logic Circuit: Flip-flops clocked RS-FF, D-FF, T-FF, JK-FF, and Shift Register
Week 10: Counters (Ring, Ripple, up-down, Synchronous) A/D and D/A Converters
Week 11: Memory Devices: ROM, PROM, EAPROM, EE PROM, RAM, (Static and dynamic) Memory mapping techniques
Week 12: Micro Computers: Computers and its types, all generation of computers, basic architecture of computer, micro-processor (ALU, UP Registers, Control and Time Section).
Week 13: Addressing modes, Instruction set and their types, Discussion on 8085/8088, 8086 processor family, Intel Microprocessor Hierarchy
Week 14: Micro-controller/ Embedded System: Introduction to Embedded and microcontroller based systems
Week 15: The Microprocessor and microcontroller applications and environment, microcontroller characteristics, features of a general purpose microcontroller
Week 16: Microchip Inc and PIC microcontroller, Typical Microcontroller examples:, Philips 80C51 & 80C552 and Motorola 68Hc05/08, Interfacing with peripherals.

Recommended Books:

1. M. M. Mono, "Digital Logic and Computer Design", Prentice Hall, 1995.
2. R. Tokheim, "Digital Electronics", McGraw Hill, 7th ed. 2007.
3. B. B. Brey, "The Intel Microprocessors: Architecture, Programming and Interfacing", Merril, 2nd ed. 1991.
4. Thomas L. Floyd, "Electronics Fundamentals: Circuits, Devices and Applications", Prentice Hall, 8th ed. 2009.
5. T. Wilmshurst, "The Design of Small-Scale Embedded Systems", Palgrave, 2001.

METHODS OF EXPERIMENTAL PHYSICS
Credit Hours: 3 (3-0)
Course Code: PHY-465

Objective(s):
To learn about the vacuum techniques. To learn the detection techniques about radiation, temperature. To learn about the measuring techniques along with data analysis.

Learning Outcomes:
after studying this course the student will learn about the vacuum techniques. And to learn the detection techniques about radiation, temperature and data analysis.

Week 1: Introduction to synthesis techniques and characterization tools
Week 2: Synthesis and characterization of OD, 1D, 2D and 3D of materials, fabrication of materials
Week 3: Vacuum techniques, Sputtering, Ion Beam, Electron Beam, CVD, XRD, EDX, SEM, TEM, Uv-Vis, FTIR, NMR, XPS, etc.
Week 4: Vacuum Techniques: Gas Transport: Throughout, Pumping Speed, Pump down Time Ultimate pressure. Fore-Vacuum Pumps:
Week 5: Rotary Oil pumps, sorption pumps. Diffusion pumps, sorption pumps (High Vacuum). Production of ultrahigh vacuum
Week 6: Fundamental concepts, guttering pumps, Ion pumps, Cryogenic pumps, Turbo molecular pumps. Measurement of total pressure in Vacuums Systems, Units pressure ranges,
Week 7: Manometers, Perini gauges, The Mc Load gauges, Mass spectrometer for partial measurement of pressure
Week 8: Design of high Vacuum system, Surface to Volume ratio, Pump Choice, pumping system design
Week 9: Vacuum Components, Vacuum valves, vacuum Flanges, Liquid Nitrogen trap, Mechanical feed through & Electrical feed through Leak detection:
Week 10: Basic consideration, leak detection equipment, Special Techniques and problems, Repair Techniques.
Week 11: Radiation Detection and Measurement: GM tubes, scintillation detector, channeltron, photo multipliers, neutron detectors, alpha/beta detectors
Week 12: X-rays/gamma detectors, cosmic rays detectors, Spectrographs and Interferometers
Week 13: Sensor Technology: Sensors for temperature, pressure displacement, rotation, flow, level, speed, rotation position, phase, current voltage, power magnetic field, tilt, metal, explosive and heat.
Week 14: Data Analysis: Evaluation of measurement: Systematic Errors, Accuracy, Accidental Errors, Precision, Statistical Methods, Mean Value and Variance

Week 15: Statistical Control of Measurements, Errors of Direct measurements, Rejection of data, Significance of results, Propagation of errors, preliminary Estimation, Errors of Computation
Week 16: Least squares fit to a polynomial. Nonlinear functions. Data manipulation, smoothing, interpolation and extrapolation, linear and parabolic interpolation.

Recommended Books:

1. F. James, "Statistical Methods in Experimental Physics", World Scientific Company, 2nd ed. 2006.
2. M. H. Hablanian, "High-Vacuum Technology", Marcel Dekker, 2nd ed. 1997.
3. P. Bevington and D. K. Robinson, "Data Reduction and Error Analysis for Physical Science", McGraw-Hill, 3rd ed. 2002.
4. S. Tavernier, "Experimental Techniques in Nuclear and Particle Physics", Springer, 2010.
5. J. B. Topping, "Errors of Observations and Their Treatment", Springer, 4th ed. 1972.
6. Materials characterization techniques, by Zhang S, L. li, and Kumar 2008 CRC press

ENVIRONMENTAL PHYSICS
Credit Hours: **3 (3-0)**
Course Code: **PHY-466**

Objective(s):
To become familiar with the essentials of environment and Global climate. To learn to use spectroscopy for environments.
Learning Outcomes:
after studying this course the students will learn the essentials of environment, Global climate. And spectroscopy for environments.

Week 1: Introduction to the Essentials of Environmental Physics
Week 2: The economic system, living in green house, enjoying the sun, Transport of matter, Energy and momentum, the social and political context.
Week 3: Basic Environmental Spectroscopy, Black body radiation, The emission spectrum of sun, The transition electric dipole moment
Week 4: The Einstein Coefficients, Lambert – Beer's law, The spectroscopy of bi-molecules, Solar UV and life, The ozone filter
Week 5: The Global Climate: The energy Balance, (Zero-dimensional Greenhouse Model), elements of weather and climate, climate variations and modeling.

Week 6: Transport of Pollutants: Diffusion, flow in reverse, ground water. Flow equations of fluid Dynamics
Week 7: Turbulence, Turbulence Diffusion, Gaussian plumes in air, Turbulent jets and planes.
Week 8: Noise: Basic Acoustics, Human Perceptions and noise criteria
Week 9: Reducing the transmission of sound, active control of sound
Week 10: Radiation: General laws of Radiation, Natural radiation
Week 11: Interaction of electromagnetic radiation and plants, utilization of photo synthetically active radiation.
Week 12: Atmosphere and Climate: Structure of the atmosphere, vertical profiles in the lower layers of the atmosphere
Week 13: Lateral movement in the atmosphere, Atmospheric Circulation, cloud and Precipitation, The atmospheric greenhouse effect.
Week 14: Topo Climates and Micro Climates: Effects of surface elements in flat and widely unduling areas, Dynamic action of seliq. Thermal action of selief.
Week 15: Climatology and Measurements of Climate Factor: Data collection and organization, statistical analysis of climatic data, climatic indices, General characteristics of measuring equipment
Week 16: Measurement of temperature, air humidity, surface wind velocity, Radiation balance, precipitation, Atmospheric Pressure, automatic weather stations

Recommended Books:

1. E.t Booker and R. Van Grondelle, "Environmental Physics", John Wiley, 3rd ed. 2011.
2. G. Guyot, "Physics of Environment and Climate", John Wiley, 1998.

INTRODUCTION TO QUANTUM COMPUTING

Pre-requisite:	**Quantum Mechanics-I, Computational Physics**
Credit Hours:	**3 (3-0)**
Course Code:	**PHY-467**

Objective(s):
To be familiar with the quantum computing. To learn about the Quantum circuits, and cryptography.

Learning Outcomes:
After studying this course the students will learn basics for quantum computing, Quantum circuits, and cryptography.

Week 1: Computer technology and historical background
Week 2: Basic principles and postulates of quantum mechanics
Week 3: Quantum states, evolution, quantum measurement
Week 4: Superposition, Quantization from bits to qubits, operator function

Week 5: Density matrix, Schrodinger equation, Schmidt decomposition
Week 6: EPR and Bell's inequality, Quantum Computation: Quantum Circuits
Week 7: Single qubit operation, Controlled operations, Measurement
Week 8: Universal quantum gates, Single qubit and CNOT gates
Week 9: Breaking unbreakable codes, Code making
Week 10: Trapdoor function, One time pad RSA cryptography
Week 11: Code breaking on classical and quantum computers
Week 12: Schor's algorithm, Quantum Cryptography
Week 13: Uncertainty principle Polarization and Spin basis
Week 14: BB84, BB90, and Ekert protocols
Week 15: Quantum cryptography with and without eavesdropping
Week 16: Experimental realization, Quantum Search Algorithm.

Recommended Books:

1. M. A. Nielson and I. L. Chuang, "Quantum Computation and Quantum Information", Foundation Books, 2007.
2. C. P. Williams and S. H. Clearwater, "Exploration in Quantum Computation" Springer, 2nd ed. 2011. .
3. P. Bouwmester, A. Ekert, and A. Zeilinger, "The Physics of Quantum Information: Quantum Cryptography, Quantum Teleportation, Quantum Computation", Springer, 2010.
4. R. K. Brylinsky and G. Chen, "Mathematics of Quantum Computation" by Chapman & Hall/CRC, 2002.

QUANTUM INFORMATION THEORY

Pre-requisites: **Quantum Mechanics-I**
Credit Hours: **3 (3-0)**
Course Code: **PHY-468**

Objective(s):
To understand the fundamental concepts of quantum information, communication, computation, and physical protocols for quantum computation.
Learning Outcomes:
After studying this course the students will learn to understand the fundamental concepts of quantum information, communication, computation, and physical protocols for quantum computation

Week 1: Review of Quantum Mechanics and overview of Quantum information

Week 2: Postulates of quantum mechanics, quantum states and observables
Week 3: Dirac notation, projective measurements, density operator, pure and mixed states,
Week 4: Entanglement, tensor products, no-cloning theorem, mixed states from pure states in a larger Hilbert space
Week 5: Schmidt decomposition, generalized measurements, (CP maps, POVMs), qualitative overview of Quantum Information
Week 6: Quantum Communication: Dense coding, teleportation, entanglement swapping, instantaneous transfer of information, quantum key distribution
Week 7: Entanglement and its Quantification: Inseparability of EPR pairs, Bell inequality for pure and mixed states
Week 8: Entanglement witnesses, Peres Horodecki criterion, properties of entanglement measures, pure and mixed state entanglement
Week 9: Relative entropy as entanglement measure, entanglement and thermodynamics, measuring entanglement
Week 10: Quantum Information: Classical information theory (data compression, Shannon entropy, von Neumann entropy), fidelity
Week 11: Helstrom's measurement and discrimination, quantum data compression, entropy and information
Week 12: Relative entropy and its statistical interpretation, conditional entropy, Holevo bound, capacity of a quantum channel, relative entropy and thermodynamics, entropy and erasure, Landauer's erasure.
Week 13: Quantum Computation: Classical computation (Turing machines, circuits, complexity theory), quantum algorithms (Deutsch's algorithm, Oracles, Grover's algorithm, factorization and quantum Fourier transform)
Week 14: Role of entanglement in algorithms (search algorithm), modeling quantum measurements, Bekenstein bound
Week 15: Quantum error correction (general conditions, stabilizer codes, 3-qubit codes, relationship with Maxwell's demon), Fault tolerant quantum computation (overview)
Week 16: Physical Protocols for Quantum Information and Computation: Ion trap, optical lattices, NMR, quantum optics, cavity QED.

Recommended Books:

1. V. Vedral, "Introduction to Quantum Information Science", Oxford University Press, 2007.
2. M. Nielsen and I. Chuang, "Quantum Computation and Quantum Information", Cambridge University Press, 10th Anv. ed. 2010.
3. W. Steeb and Y. Hardy, "Problems and Solutions in Quantum Computing and Quantum Information", World Scientific Publishing, 3rd ed. 2011.
4. Book on general quantum mechanics: A. Peres, Quantum Theory: Concepts and Methods, Kluwer Academic Publishers (2002).
5. Seth Lloyd's notes on quantum information available online at:

web.mit.edu/2.111/www/notes09/spring.pdf

QUANTUM FIELD THEORY

Pre-requisites: **Quantum Mechanics-II**
Credit Hours: **3 (3-0)**
Course Code: **PHY-469**
Objective(s):
To understand the fundamental concepts of quantum field theory, QED, Quantized Dirac field. Feynman rules for QED, Cross sections and decay rates.
Learning Outcomes:
After studying this course, the students will learn to understand the fundamental concepts of quantum field theory, QED, Quantized Dirac field. Feynman rules for QED, Cross sections and decay rates.
Week 1: Introduction to Lagrangian Field Theory
Week 2: Classical Field Theory
Week 3: Canonical Quantization Noether's theorem
Week 4: Klein-Gordon Field
Week 5: Real Klein-Gordon field. Complex Klein-Gordon field
Week 6: Covariant commutation relations. Meson propagator
Week 7: Dirac Field: Number representation for fermions
Week 8: Quantization of Dirac field
Week 9: Spin-statistics theorem. Fermion propagator
Week 10: Electromagnetic Field: Classical electromagnetic field
Week 11: Covariant quantization. Photon propagator
Week 12: Interacting Fields
Week 13: Interaction Lagrangian and gauge invariance
Week 14: Interaction picture. S-matrix expansion
Week 15: Wick's theorem. Feynman Diagrams
Week 16: Feynman rules for QED. Cross sections and decay rates.

Recommended Books:

1. F. Mandl and G. Shaw, "Quantum Field Theory", Wiley, 2nd ed. 2010.
2. M. E. Peskin and D. V. Schroeder, "An Introduction to Quantum Field Theory", Addison Wesley, 1995.
3. S. Weinberg, "The Quantum Theory of Fields", Vol. 1, Cambridge University Press, 1999.
4. N. N. Bogoliubov and D. V. Shirkov, "Introduction to the Theory of Quantized Fields", John Wiley, 1980.

LASERS

Pre-requisite: **Quantum Mechanics-II, Atomic and Molecular Physics**
Credit Hours: **3 (3-0)**
Course Code: **PHY-470**

Objective(s):
Develop fundamental concepts about lasers. Learn the principles of spectroscopy of molecules and semi-conductors. Understand the optical resonators and laser system. Applications of lasers.

Learning Outcomes:
After studying this course the student will be able to learn and understand fundamental concepts about lasers, principles of spectroscopy of molecules and semi-conductors, Understand the optical resonators and laser system.

Week 1: Introductory Concepts: Spontaneous Emission, Absorption, Stimulated Emission

Week 2: Pumping Schemes, Absorption and Stimulated Emission Rates, Absorption and Gain Coefficients

Week 3: Resonance Energy Transfers. Properties of Laser Beam: Monochromaticity, Coherence, Directionality, Brightness

Week 4: Spectroscopy of Molecule and Semiconductors: Electronic Energy Levels, Molecular Energy Levels, Level Occupation at Thermal Equilibrium

Week 5: Stimulated Transition, Selection Rules, Radiative and Nonradiative Decay, Semiconductor.

Week 6: Optical Resonators: Plane Parallel (Fabry-Perot) Resonator, Concentric (Spherical) Resonator

Week 7: Confocal, Resonator, Generalized Spherical Resonator

Week 8: Pumping Processes: Optical pumping: Flash lamp and Laser, Threshold Pump Power,

Week 9: Pumping efficiency, Electrical Pumping: Longitudinal Configuration and Transverse Configuration

Week 10: Gas Dynamics Pumping, Chemical Pumping, Rate Equations

Week 11: Threshold Condition and Output Power, Optimum Output Coupling, Laser Tuning

Week 12: Oscillation and Pulsations in Lasers, Q-Switching and Mode-Locking Methods

Week 13: Phase Velocity, Group Velocity, and Group-Delay Dispersion, Line broadening.

Week 14: Lasers Systems, Solid State Lasers: Ruby Laser, Nd: YAG & Nd: Glass Lasers and Semiconductor Lasers

Week 15: Homojunction Lasers Double Heterostructure lasers, Gas lasers: Helium Neon laser, CO2 laser, Nitrogen Laser and Excimer Lasers, Free-Electron and X-Ray Lasers

Week 16: Laser Applications: Material Processing: Surface Hardening, Cutting, Drilling, Welding etc. Holography, Laser Communication, Medicine, Defense Industry, Atmospheric Physics.

Recommended Books:
1. O. Svelto, “Principles of Lasers”, Springer, 5th ed. 2009.

2. J. Eberly and P. Milonni, “Lasers Physics”, John Wiley, 2nd ed. 2010.
3. M. O. Scully and M. S. Zubairy, “Quantum Optics”, Cambridge University Press, 1997.
4. W. T. Silfvast, “Laser Fundamentals”, Cambridge University Press, 2nd ed. 2008.
5. W. M. Steen, J. Mazumder and K. G. Watkins, “Laser Material Processing”, Springer, 4th ed. 2010.

EXPERIMENTAL TECHNIQUES IN PARTICLE AND NUCLEAR PHYSICS

Pre-requisites: **Particle Physics, Nuclear Physics**
Credit Hours: **3 (3-0)**
Course Code: **PHY-471**

Objective(s):
To give students with the practical hand on the experimental techniques and to physically understand the nuclear phenomena.
Learning Outcomes:
After studying this course the students will be able to perform practical hand on the experimental techniques and to Physically understand the nuclear phenomena.

Week 1: Review of Basic Concepts: Units used in particle physics, Definition used in particle physics, Types of particles to be detected
Week 2: Cross section, Decay width, Lab Frame and CM frame, Pseudo rapidity
Week 3: History of Accelerator, Linear accelerators, Circular accelerators, Introduction to RHIC, Tevatron, LEP, LHC.

Week 4: Introduction to Accelerators: Lattice and geometry, The arcs, Periodicity, Aperture, Beam crossing angle, Luminosity, RF cavities
Week 5: Power requirements, Longitudinal feedback system, Injection, Injection scheme, PS, SPS, Magnets, Cryogenics, Vacuum system.
Week 6: Introduction to detectors, Need of detectors, Passage of radiation through matter, Cross-section, Interaction probability in a distance x
Week 7: Mean free path, Energy loss of heavy charged particles by atomic collisions, Bohr’s, calculation – classical case - The Bethe Bloch formula, Cherenkov radiation
Week 8: Energy loss of electron and photon, Multiple coulomb scattering, Energy straggling, The interaction of photons, The interaction of neutrons.
Week 9: General Characteristics of Detectors and Gas Detectors: Sensitivity, Detector response, Energy resolution The Fano-factor, The response function, Response time

Week 10: Detector efficiency, Dead time- Ionization detectors, Gaseous ionization detectors,
Week 11: Ionization & transport phenomenon in gases, Transport of electrons and ions in gases, Avalanche multiplication
Week 12: The cylindrical proportional counter, The multi-wire proportional counter, The drift chambers, Time projection chambers, Liquid ionization detector. Scintillators, Photomultipliers,
Week 13: Semi-conductor Detectors: Scintillation detectors, Organic scintillation, Inorganic crystals, Gaseous scintillators Glasses, Intrinsic detector efficiency for various radiations, Photomultipliers, Basic construction and operation
Week 14: The photocathode, The electron-optical input system, Semiconductor detectors, Silicon diode detectors, Introduction to CMS and its detectors.

Week 15: Detector Software and Physics Objects: Introduction to Linux operating system, Introduction to CMS software (CMSSW), Basic infrastructure of software
Week 16: Introduction to PYTHIA, Introduction to GEN, SIM, DIGI, RECO, reconstruction of final state objects.

Recommended Books:

1. The Large Hadron Collider Conceptual Design CERN/AC/95-05 (LHC)
2. Detector performance and software, Physics Technical Design Report, Volume1
3. Techniques for Nuclear and Particle Physics Experiments by W.R. Leo
4. R. Fernow, "Introduction to experimental particle physics", Cambridge University Press, 1989.
5. D. H. Perkins, "Introduction to High Energy Physics", Cambridge University Press, 4th ed. 2000.

FLUID DYNAMICS

Pre-requisites: **Mechanics, Calculus-I, Differential Equations**
Credit Hours: **3 (3-0)**

Course Code: **PHY-472**
Objective(s):
To know the fundamentals of Fluid Dynamics and its applications in order to physically understand it.
Learning Outcomes:
After studying this course the students will be able to physically understand the fundamentals of Fluid Dynamics and its applications.
Week 1: Phenomenological introduction to fluid dynamics
Week 2: Kinematics and conservation laws
Week 3: Ideal fluids
Week 4: The Euler equations
Week 5: Ir-rotational flow

Week 6: The Navier-Stokes equations
Week 7: Viscous flow: Stokes flow
Week 8: Drag, lubrication theory
Week 9: Thin film flow, Waves
Week 10: surface waves, internal gravity waves
Week 11: nonlinear waves. solitons, shocks
Week 12: Instabilities: linear stability analysis
Week 13: Kelvin-Helmholts instability, Rayleigh Bénard convection
Week 14: Other instabilities
Week 15: Other topics depending on interest and as time permits possibly: airfoil theory, granular flows
Week 16: biophysical flows

Recommended Books:

1. D. J. Acheson, "Elementary Fluid Dynamics", Oxford University Press, 1990.
2. P. K. Kundu and I.M. Cohen, "Fluid Mechanics", Academic Press, 4th ed. 2010.
3. D. J. Tritton, "Physical Fluid Dynamics", Clarendon, 2nd ed. 1988.
4. L. D. Landau and E. M. Lifschitz, "Fluid Mechanics", Butter worth Heinemann, 2nd ed. 1987.

INTRODUCTION TO PHOTONICS

Pre-requisites:	**Waves and Oscillations, Optics, Linear Algebra, Electronics-I**
Credit Hours:	**3 (3-0)**
Course Code:	**PHY-473**

Objective(s):
To study the application of light and studying the photonic devices including detectors.

Learning Outcomes:
After studying this course the students will be able to know about the application of light and photonic devices including detectors.

Week 1: Guided Wave Optics: Planar slab waveguides, Rectangular channel waveguides
Week 2: Single and multi-mode optical fibers
Week 3: Waveguide modes and field distributions
Week 4: Waveguide dispersion, pulse propagation
Week 5: Gaussian beam Propagation: ABCD matrices for transformation of Gaussian beams,
Week 6: Application to simple resonators
Week 7: Electromagnetic Propagation in Anisotropic Media: Reflection and transmission at anisotropic interfaces

Week 8: Jones Calculus, retardation plates, polarizers
Week 9: Electro-optics and Acousto-optics: Linear electro-optic effect
Week 10: Longitudinal and transverse modulators, amplitude and phase modulation
Week 11: Mach-Zehnder modulators, Coupled mode theory
Week 12: Optical coupling between waveguides, Directional couplers, Photoelastic effect,
Week 13: Acousto-optic interaction and Bragg diffraction, Acousto-optic modulators, deflectors and scanners
Week 14: Optoelectronics: p-n junctions, semiconductor devices
Week 15: laser amplifiers, injection lasers,
Week 16: Photoconductors, Photodiodes

Recommended Books:

1. B. E. A. Saleh and M. C. Teich, "Fundamentals of Photonics", John Wiley, 2nd ed. 2007.
2. J-M. Liu, "Photonic Devices", Cambridge University Press, 2009.
3. A. Yariv and P. Yeh, "Photonics: Optical Electronics in Modern Communications", Oxford University Press, 2006.
4. E. Hecht, "Optics", Addison-Wesley, 4th ed. 2001.

PARTICLE PHYSICS

Pre-requisites: **Quantum Mechanics-II, Nuclear Physics**
Credit Hours: **3 (3-0)**
Course Code: **PHY-474**
Objective(s):
To know about the elementary particles, their classification and about the interactions among these particles.
Learning Outcomes:
After studying this course the students will have sufficient knowledge about the elementary particles, the ways they are classified and about the interactions among these particles.
Week1: Introduction to Elementary Particles,
Week2: Fundamental building blocks and their interactions.
Week3: Quantum Electrodynamics. Quantum Chromodynamics. Weak interactions. Decays and conservation laws
Week4: Relativistic Kinematics, Lorentz transformations. Four-Vectors.
Week5: Energy and momentum. Particle collisions. Mandelstam variables.
Week6: Symmetries, Symmetries and conservation laws,
Week7: Spin and orbital angular momentum. Flavour symmetries, Parity.
Week8: Charge conjugation. CP Violation.

Week9: Time reversal and TCP Theorem.
Week10: Quantum Electrodynamics, Klein-Gordon equation.
Week11: Dirac equation. Solution of Dirac equation. Bilinear covariants. Feynman rules for QED.
Week12: Casmir's trick. Cross sections & lifetimes.
Week13: Neutrino Oscillations, Solar neutrino problem. Oscillations, Neutrino masses. PMNS mixing matrix.
Week14: Gauge Field Theories, Lagrangian in Relativistic Field Theory. Gauge Invariance. Yang-Mills Theory.
Week15: The mass term. Spontaneous symmetry breaking. Higgs mechanism, Higgs boson.
Week16: Grand Unification. Supersymmetry. Extra dimensions. String theory. Dark energy. Dark Matter.

Recommended Books:
1. D. Griffiths, "Introduction to Elementary Particles", Wiley-VCH, 2nd ed. 2008.
2. F. Halzen and A.D. Martin, "Quarks and Leptons: An introductory course in modern Particle Physics", John Wiley, 1984.
3. D. H. Perkins, "Introduction to High-Energy Physics", Cambridge University Press, 4th ed. 2000.
4. V. D. Barger and R. J. N. Phillips, "Collider Physics", Addison-Wesley, 1996.

COMPUTER SIMULATIONS IN PHYSICS

Pre-requisites:	**Calculus-II, Linear Algebra, Probability and Statistics, Differential Equations, Introduction to Computing, Mechanics.**
Credit Hours:	**3 (3-0)**
Course Code:	**PHY-475**

Objective(s):
The aim is to develop the ability to turn theoretical ideas of mathematics and physics into computer simulations of real-world systems.
Learning Outcomes:
After studying this course the students will learn techniques to understand and develop computer simulations, to solve the differential equations and to understand the simulation in classical physics and Quantum Physics.
Week1: Introduction to computer simulation.
Week2: Programming for Scientific Computation,
Week3: Unix/Linux basics,

Week4: the editingcoding-compiling-debugging-optimizing-visualizing-documenting
Week5: production chain, Fortran95.
Week6: Numerical Programming, Functions, approximation and fitting,
Week7: Numerical calculus.
Week8: Ordinary differential equations, Matrices, Spectral analysis,
Week9: Partial differential equations.
Week10: Modeling and Simulation, Molecular dynamics simulations,
Week11: modeling continuous media Monte Carlo simulations.
Week12: Project, A project will be chosen by the student in consultation with the instructor.
Week13: Selection of the project should be done soon after
Week14: The module on modeling and simulation.
Week15: The final part of the course is reserved for presentation of preliminary and final results.
Week16: Applications of simulations in Physics.

Recommended Books:

1. T. Pang, "An Introduction to Computational Physics", Cambridge University Press, 2008.
2. R. Landau, M. Paez, C. Bordeianu, "A Survey of Computational Physics", Princeton University Press, 2008.

SURFACE SCIENCES

Pre-requisite:	**Solid State Physics-II**
Credit Hours:	**3 (3-0)**
Course Code:	**PHY-476**

Objective(s):
To understand the basics of surface physics and its applications and to learn about the interaction of surface with the ions, electrons etc.

Learning Outcomes:
After studying this course the students will be able to understand the basics of surface physics and its applications. In addition they will have sufficient knowledge about the interaction of surface with the ions, electrons etc.

Week1: Basics of Surface Science, Surface reactions, Heterogeneous catalysis, Semiconductor technology, Corrosion, Nanotechnology,
Week2: Surface Structure and Reconstruction: Classification of solids, Crystal structure, Unit cell, Bravais lattices, Electronic Structure of Surfaces: Band structure of metals, insulators and semiconductors, Fermi level, Screening,
Week3: Work Function, Surface States, Electron Affinity, Ionization Potential, Surface Chirality, Thermodynamics of Surfaces, Equilibrium Crystal Shape.

Week4: Quantum confinement of Electrons at Surfaces, Interference of Electron Waves, Quantum size effects, Quantum wells, Mechanical Quantum Wells, Quantum Wires, Chemist's Approach, Bonds to Bands.
Week5: Surface Dynamics, Nucleation and growth of nanostructures and films, Surface Magnetism and magnetic imaging, Diamagnetism,
Week6: Paramagnetism, Anti-Ferromagnetism, Magnetism in thin films, Kerr microscopy (MOKE), Spin Polarized Photoemission (SP-PEEM), Magnetic Force Microscopy.
Week7: Surface Study Techniques, Surface Sensitivity and specificity, Explanation and comparison of Low-Energy Electron Diffraction (LEED) and Reflection High-Energy Electron Diffraction (RHEED),
Week8: Explanation of Near-Edge X-ray Absorption Fine Structure (NEXAFS), High-Resolution Electron Energy Loss Spectroscopy (HREELS),
Week9: Introduction to Desorption Techniques, Thermal Desorption Spectroscopy (TDS), Electron Stimulated Desorption (ESD),
Week10: Electron Stimulated Desorption Ion Angular Distribution (ESDIAD), Photon Stimulated Desorption (PSD), Electron Spectroscopy, Theory: Mean free path, Koopman's Theorem, Spin orbit coupling effects, chemical shifts, binding energy,
Week11: Auger Electron Spectroscopy (AES),X-Ray Photo-electron Spectroscopy, Electron Analyzer, Electron optics, Scanning Tunneling Microscopy (STM), History, Theory, Electronics and applications.
Week12: Case Studies, Silicon Surfaces: Geometric and Electronic Structure, Molecular Adsorption on Semiconductor Surfaces.
Week13: Adsorption Properties of CO on Metal Single-Crystal Surfaces, Molecular or dissociative adsorption, Chemical bonding and Orientation, Adsorption Site as a function of coverage, Over layer long-range order.
Week14: Ammonia Synthesis, Oxide Surfaces. Photovoltaic and Organic Electronics, Different types of semiconductors (organic, inorganic, conjugated polymers),
Week15: Prototypes (OLEDs etc.), intermolecular bonding, Van der Waals.
Week16: Electronic properties, polarization effects, Field effect Transistors, basics of excitonic solar cells.

Recommended Books:

1. A. Zangwill, "Physics at Surfaces", Cambridge University Press, 1988.
2. D. P. Woodruff and T. A. Delchar, "Modern Techniques of Surface Science", Cambridge University Press, 2nd ed. 1994.
3. D. Briggs and M. P. Seah, "Practical Surface Analysis", Vol-I, John Wiley, 2nd ed. 1990.
4. J. B. Hudson, "Surface Science, an Introduction", Wiley-Interscience, 1998.
5. H. Luth, "Surfaces and Interfaces of Solids", Springer-Verlag, 2nd ed. 1993.
6. M. Prutton, "Introduction to Surface Physics", Oxford University Press, 1994.
7. R. I. Masel, "Principles of Adsorption and Reaction on Solid Surfaces", Wiley-Interscience,

1996.

COMPUTATIONAL PHYSICS

Credit Hours: **3 (3-0)**
Course Code: **PHY-477**

Objective(s):
To introduce the students with computer languages and the use of computer in numerical analysis, computer simulations and modeling.
Learning Outcomes:
After studying this course the students will have clear understanding of computer languages and the use of computer in numerical analysis, computer simulations and modeling.
Week1: Introduction to computational Physics
Week2: Computer Languages,
Week3: A brief introduction of the computer languages like Basic,
Week4: C. Pascal etc. and known software packages of computation.
Week5: Numerical Methods, Numerical Solutions of equations, Regression and interpolation,
Week6: Numerical integration and differentiation.
Week7: Error analysis and technique for elimination of systematic and random errors.
Week8: Modeling & Simulations,
Week9: Conceptual models, the mathematical models,
Week10: Random numbers and random walk, doing Physics with random numbers,
Week11: Computer simulation, Relationship of modeling and simulation.
Week12: Some systems of interest for physicists such as Motion of Falling objects,
Week13: Kepler's problems, Oscillatory motion, many particle systems,
Week14: Dynamic systems, Wave phenomena, Field of static charges and current,
Week15: Diffusion, Populations genetics etc.
Week16: Developing programming skill with Physics problems.

Recommended Books:
1. M. L. De Jong, ”Introduction to Computational Physics”, Addison Wesley, 1991.
2. S. T. Koonini, “Computational Physics”, the Benjamin-Cummings, 1985.
3. H. Gould, J. Tobochnik and W. Christian, “An Introduction to Computer Simulation Methods”, Addison Wesley, 3rd ed. 2006.
4. S. C. Chapra and R. P. Chanle, ”Numerical Methods for Engineers with Personal Computer Applications”, McGraw-Hill,1990.
5. S. C. Chapra, “Applied Numerical Methods with MATLAB for Engineers and Scientists”, McGraw-Hill, 2nd ed. 2006.

CLAY SCIENCE

Pre-requisite: **Solid State Physics-I**
Credit Hours: **3 (3-0)**
Course Code: **PHY-478**

Objective(s):
The objective of this course is to study Clay Science, its applications and the use of various characterization techniques in Clay Science.

Learning Outcomes:
After studying this course the students will have clear understanding of the fundamental concepts used in Clay Science and its applications. The students will have also adequate knowledge about the various characterization techniques used in Clay Science.

Week 1: General Introduction: History of clay science, Aim and Scope of clay science, Clay.

Week 2: Clay Mineral, Distinction between clay and clay minerals, clay mineral properties, associated minerals, associated phases, other solids with similar properties.

Week 3: Clay mineral particle and aggregates, clay mineral and environments, Alternative concept of clay minerals, Clay science.

Week 4: Structure and Mineralogy of clay minerals: General structure information, Layer charge, polytypism, mixed layer structures,

Week 5: The 1:1 llayer: Dioctahedral 1:1 layer minerals (the kaolin group- kaolinite, Dickite, Nacrite,

Week 6: Halloysite, Hisingrite), Trioctahderal 1:1 minerals, the serpentine group, The 2:1 layer pyrophyllite, Talc,and related minerals, True and brittle mica, Illite, Smectite, Vermiculite, chlorite,

Week 7: Illite-smectite and other interstratifications between dioctahedral non-xepandable and expandiable 2:1 layers, Allophane and imogolite, polygroskite

Week 8: Surface and interface chemistry of clay minerals: Surface atoms, surface structures and properties, constant charge sites, the hydroxyl surface, clay water interactions,

Week 9: Structure and properties of sorbed to clay mineral surface, influence of water on clay mineral structure, surface chemistry in aqueous dispersions,

Week 10: Organization of clay mineral particles and molecules, Synthetic clay minerals and purification of natural clays: Methodology, Synthesis of specific clay minerals (like micas, smectites, kaolinite, sepolite),

Week 11: Purification of clays, purification procedures (decomposition of carbonates, recommended procedures, dissolution of (Hydro) oxides, oxidation of organic materials,

Week 12: Dissolution of silica, removal of remaining salt by dialysis and fractionation, a simplified gentle purification method, a pilot purification technique.

Week 13: Properties and modification of clays: General properties, water interaction, hydraulic conductivity, gas penetrability,

Week 14: Ion diffusivity, mechanical properties, acid activation, thermal modification, dehydroxylated phases, High temperature phases, Assessment of some analytical technique:

Week 15: X-ray absorption spectroscopy, X-ray photoelectron microscopy, Fourier transformation infrared spectroscopy, nuclear magnetic resonance microscopy,

Week 16: Scanning electron microscopy, XRD analysis, TEM, Thermal analysis

Main Text Book

2. F Bergaya, BKG Theng and G Lagaly, "Development in clay Science, 1, Handbook of clay Science", Elsever Ltd, 2006.

Reference books:

4. SW Bailey, "Volume 19: Hydrous Phyllosilicates (exclusive mics)", Mineralogical Society of America, 1988.
5. A K Chakarborty, "Phase Transformation of kaolinite clay", Springer India 2014.

V.S. Ramachandran, Ralph M. Paroli, James J. Beaudoin, and Ana H. Delgado, "Handbook of Thermal Analysis of Construction Materials", Noyes Publications, 2002

Annexure "L"

LABORATORY COURSES IN M.Sc. PHYSICS (2 YEAR) PROGRAM

Students will take three laboratory courses, Labs V, VI and VII, each of two credit hours.

Mathematical and conceptual outcomes:

1. Demonstrate a keen appreciation of physical quantities, their dimensions and units.
2. Perform simple statistical analysis of data including calculating means, mean squares, root mean squares, standard deviations and correlations between groups of data.
3. Mathematically understand physical processes and fitting them with linear, exponential, sinusoidal and polynomial models.
4. Accurately represent experimental data in the form of tables and graphs.
5. Understand errors, uncertainties and their propagation from basic to deduced quantities. Students must possess the ability to calculate uncertainties and appreciate types A and B of uncertainties. Students must appreciate when experiments are repeatable and reproducible, determine and understand the concepts of precision and accuracy, resolution and time for measurement.
6. Students must be able to develop a keen sense of measurement theory in accordance with the guidelines presented in the "Guide to the Expression of Uncertainties in Measurement" as formulated by ISO's Joint Committee for Guides in Metrology (as of November 2012, these guides are downloadable from http://www.iso.org/sites/JCGM/GUMintroduction.htm).
7. Students must possess the ability to present an idea in the following equivalent forms: (a) equations and formulas, (b) words, (c) graphs, (d) pictures and sketches.

8. Develop an appreciation of energy, its myriad manifestations and inter-conversion.

Engineering and Practical Outcomes:

1. Perform experiments to test physical ideas, corroborate physical theories, find correspondence between theory and experiment, understand the limitations of theoretical descriptions and the role of approximations in physics.
2. Design simple experiments to test physical ideas.
3. Understand the significance of various kinds of materials (ceramics, plastics, metals, conductors, insulators) in the design of hardware.
4. Perform experiments safely.
5. Demonstrate the ability to work in teams.
6. Use locally available resources including materials and craftsmanship to build new projects.
7. Familiarity with mechanical workshop and ability to interpret basic engineering drawings.
8. Specializing in the skill of logging laboratory activity and producing high quality reports of experimental work.
9. Obtaining basic familiarity with advanced scientific instrumentation and its role in the progress of physics and science. Students must also possess the appreciation of limitations in accuracy and precision of the apparatus they use and the ability to suggest improvements in the equipment, the experimental procedure and the processing of data.
10. Students should be invariably introduced at some stage during the lab courses to these modern techniques that have now become routine in laboratories worldwide: (a) data acquisition which is the transfer of experimental data from the physical apparatus to the computer using analog-to-digital converters, (b) use of some modern software (e.g. Matlab, Origin, Mathematica, C++) for statistical processing and presentation of data.

Course	**Semester**	**Credit Hours**	**Themes**
Lab-V	1	2	• electronics

Lab-VI	2	2	• Modern Physics • Advanced optics, atomic physics and spectroscopy Electronic materials
Lab-VII	3	2	• Miscellaneous advanced experiments in modern physics, atomic physics, solid state physics, electronics

Optics (basic and advanced) and Spectroscopy: Sources of light including bulbs, light emitting diodes, laser diodes and gas lasers, experiments demonstrating optical phenomena such as interference, diffraction, linear motion, reflection, refraction, dispersion, Michelson interferometry, measurement of refractive index using interferometry, measurement of the speed of light, diffraction gratings and multiple-slit interference, thin film interference and Newton's rings, use of digital cameras for optics experiments, mode structure of lasers, use of spectrometers and monochromators, wavelength tuning of laser diodes, rainbows, emission spectroscopy of low-pressure gases (hydrogen), alkali spectra and fine structure, hyperfine structure of rubidium, vibrational spectrum of nitrogen, Lambert-Beer's law, optical polarization, magneto-optical faraday rotation.

Electronics: DC voltages and current measurement, simple DC circuits, generating and analyzing time-varying signals, opamps and comparators, amplifier design, RC transients, filters, frequency response, LC circuits, resonance, transformers, diodes, modulation and radio reception, MOSFET characteristics and applications, principles of amplification, bipolar transistors and amplifiers, digital logic circuits, gates and latches, D-flip flops and shift registers, JK flip-flops and ripple counters.

Modern Physics: photoelectric effect, Frank-Hertz's quantization of energy levels, determination of Planck's constant (e.g. using a light bulb), verification of Moseley's law using X-ray fluorescence, Compton effect, Millikan's experiment for determination of charge of electron, properties of nuclear radiation (absorption in different media and response to external magnetic fields), statistical nature of radioactivity, determination of the half-life of radioisotopes, Giger-Muller tubes, cloud chambers, energy spectroscopy of gamma rays, experiments on medical physics.

Electronic Materials: measurement of electrical conductivity by two-probe and four-probe methods, band gap estimation of intrinsic and extrinsic semiconductors, carrier lifetimes and mobilities, Hall effect and its application in measuring magnetic fields, thermoelectric effects. **Advanced Experiments:** nuclear magnetic resonance, electron spin resonance, Zeeman effect, optical pumping, lifetime of muons, surface plasmon resonance, Brownian motion, experiments with vacuum, low temperature physics, superconductivity, synthesis of nanomaterials and their characterization, electromagnetically induced transparency, Mossbauer spectroscopy. **Recommended Books:**

1. A. C. Melissinos and J. Napolitano, “Experiments in Modern Physics”, Academic Press, 2nd ed.2003.
2. J. H. Moore, C. C. Davis, M. A. Coplan, and S. C. Greer, "Building Scientific Apparatus", Cambridge University Press, 4th ed. 2009.
3. J. R. Taylor, "An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements", University of Science Books, 2nd ed. 1996.
4. L. Kirkup and R. B. Frenkel, “An Introduction to Uncertainty in Measurement”, Cambridge University Press, 2006.
5. G. L. Squires, "Practical Physics", Cambridge University Press, 4th ed. 2001.
6. Y. Tsividis, "A First Lab in Circuits and Electronics", John Wiley 2001.