2nd BOARD OF STUDIES

BS Physics Program

Meeting Held on:

28th January 2021

Department of Applied Physical & Material Sciences

University of Swat

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.	Prof. Dr. Muhammad Qasim Dean Faculty of Chemical Sciences, University of Swat	**Convener**
2.	Prof. Dr. Aurangzeb Khan Professor, Department of Physics, AWKUM / Vice Chancellor, University of Lakki Marwat	**Member**
3.	Prof. Dr. Fida Younus Khattak Department of Physics, Kohat University of Science and Technology, Kohat	**Member**
4.	Prof. Dr. Nawazish Ali Khan Department of Physics, Quaid-e-Azam University, Islamabad	**Member**
5.	Prof. Dr. Anisa Qamar Department of Physics, University of Peshawar	**Member**
6.	Dr. Arif Ullah Associate Professor, Department of Physics, University of Malakand	**Member**
7.	Dr. Arbab Safeer Ahmad Assistant Prof. Islamia College University, Peshawar	**Member**
8.	Dr. Amin ur Rashid In-charge, Department of Applied Physical and Material Sciences, University of Swat	**Member**
9.	Dr. Kefayat Ullah Assistant Professor, Department of Applied Physical and Material Sciences, University of Swat	**Member**
10.	Dr. Fazli Hadi Assistant Professor, Department of Applied Physical and Material Sciences, University of Swat	**Member**

MISSION STATEMENT OF THE DEPARTMENT

Our mission is to produce well trained graduates in Physics, promoting a research culture and to serve our community in the best possible way.

VISION OF THE DEPARTMENT

We envision our department to be acknowledged as a teaching and research institution of the national as well as international level; which is recognized for its excellence both in teaching and research.

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 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 Physics Programs are:

- 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.
- To develop critical skills necessary for solving unknown problems from our physical surroundings.
- 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.

- To instill in students, the habit of independent thinking, deep inquiry, and motivation for self-education.
- To sharpen our students' mathematical prowess making them capable of modelling, analyzing and predicting the behavior of physical processes.
- To enhance our students skills in scientific communication and the ability to clearly present physics and science in simple and clear language.
- To introduce students with the spirit of working in interactive groups with the necessary requirements of scientific and professional ethics.
- To develop hands-on experience in different laboratory techniques and modern instrumentation.
- To enhance student competence in the design and conduct of experiments and analysis and presentation of experimental data and results.
- To provide an in-depth understanding of some specialized area of physics through the option of elective courses.
- 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

Expected outcomes of the Physics programs are:

- To know the importance of physics and its techniques to solve real life problems.
- To pose new physics questions and to find solutions to these questions.
- To serve Physics based positions.
- Taking interest for higher education in various areas of Physics.
- Identifying fundamental concepts of Physics and its role to connect pure and applied physics.

Annexure A

LAYOUT OF BS (4-YEARS) PHYSICS

Compulsory Requirements (the student has no choice)		General Courses to be chosen from other departments		Discipline Specific Foundation Courses	
11 Courses		**5 Courses**		**12 Courses**	
31 Credit Hours		**15 Credit Hours**		**26 Credit Hours**	
Subject	**Cr. Hrs.**	**Subject**	**Cr. Hrs.**	**Subject**	**Cr. Hrs.**
1. English-I	3(3-0)	1. GOF-I	3(3-0)	1. Mechanics – I	2(2-0)
2. English-II	3(3-0)	2. GRF-I	3(3-0)	2. Mechanics - II	3(3-0)
3. English-III	3(3-0)	3. GOF-II	3(3-0)	3. Waves and Oscillations	3(3-0)
4. English-IV	3(3-0)	4. GRF-II	3(3-0)	4. Heat & Thermodynamics	3(3-0)
5. Pakistan Studies	2(2-0)	5. GRF-III	3(3-0)	5. Fundamentals of Electricity	2(2-0)
6. Islamic Studies	2(2-0)			6. Fundamentals of Magnetism	3(3-0)
7. Calculus-I	3(3-0)			7. Modern Physics	3(3-0)
8. Calculus-II	3(3-0)			8. Optics	3(3-0)
9. Linear Algebra	3(3-0)			9. Lab-I	1(0+1*)
10. Ordinary Differential Equations	3(3-0)			10. Lab-II	1(0+1)
				11. Lab-III	1(0+1)
11. Introduction to Computing	3(3-0)			12. Lab-IV	1(0+1)
	31		**15**		**26**

Major courses including research project/internship		**Elective Courses within the major**	
19 Courses		**4 Courses**	
54 Credit hours		**12 Credit Hours**	
Subject	**Cr. Hrs.**	**Subject**	**Cr. Hrs.**
1. Mathematical Methods of Physics–I	3(3-0)	1. Elective-l	3(3-0)
2. Electrodynamics-I	3(3-0)	2. Elective-II	3(3-0)
3. Classical Mechanics-I	3(3-0)	3. Elective-III	3(3-0)
4. Electronics I	3(3-0)	4. Elective–IV	3(3-0)
5. Mathematical Methods of Physics–II	3(3-0)		
6. Quantum Mechanics – I	3(3-0)		
7. Electrodynamics-II	3(3-0)		
8. Classical Mechanics-II	3(3-0)		
9. Statistical Mechanics	3(3-0)		
10. Quantum Mechanics – II	3(3-0)		
11. Atomic and molecular physics	3(3-0)		
12. Solid State Physics I	3(3-0)		
13. Electronics II	3(3-0)		
14. Nuclear Physics	3(3-0)		
15. Solid State Physics II	3(3-0)		
16. Research Project	3(3-0)		
17. Lab-V	2(0+2)		
18. Lab-VI	2(0+2)		
19. Lab-VII	2(0+2)		
	54		**12**

1* Credit Hours of Lab means two contact hours.

Total Credit Hours: 138

GOF = General Subjects from other faculty

GRF = General Subjects from relevant faculty

NOTE:
Credit hours requirement for the award of BS-Physics degree 138

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

	Categories	**No. of Courses**	**Credit Hours**
C	Compulsory Requirements (no choice)	11	31
G	General Courses (to be chosen from other departments)	5	15
F	Discipline Specific Foundation Courses	8	22
M	Major Courses including research project	16	48
L	Lab courses	7	10
E	Electives	4	12
Total		51	138

Note: The number of Elective Courses are 04 (Four) for project students.
The Non - Project Students will take 05 (Five) Elective Courses.

ELIGIBILITY CRITERIA FOR BS-PHYSICS (4 YEAR) PROGRAM

F.Sc. or equivalent with at least 45 % marks in the subject of Physics.

SEMESTERWISE BREAKDOWN OF BS-PHYSICS COURSES

First Year

Semester-I

C. Code	Courses Title	Cr. Hrs.	Remarks	PR/CR
ENG-103	English-I	3(3-0)	Comp-1	----
MTH-104	Calculus-I	3(3-0)	Comp-7	----
CSC-105	Introduction to Computing	3(3-0)	Comp-11	----
PHY-101	Mechanics – I	2(2-0)	Found-1	----
PHY-106	Heat & Thermodynamics	3(3-0)	Found-4	MTH-104
ECO-108	Introductory Economics	3(3-0)	(GOF-I)	----
PHY-102	Lab-I	1 (0-1)	Found-3	----
MTH-107	Basic Mathematics	0 (0-0)	Non-Credit	----
	Total Credit Hours	**18**		

Semester-II

C. Code	Courses Title	Cr. Hrs.	Remarks	PR/CR
ENG-156	English-II	3(3-0)	Comp-2	ENG-103
MTH-154	Calculus-II	3(3-0)	Comp-8	MTH-104
PHY-151	Mechanics – II	3(3-0)	Found-2	PHY-101
PHY-152	Fundamentals of Electricity	2(2-0)	Found-5	PHY-101, MTH-104 / MTH-154, PHY-151
CHE-155	Chemistry-I	3(3-0)	(GRF-II)	----
PHY-153	Lab-II	1 (0-1)	Found-7	----
STA-157	Statistics-I	3(3-0)	(GRF-I)	----
	Total Credit Hours	**18**		

Second Year

Semester-III

C. Code	Courses Title	Cr. Hrs.	Remarks	PR/CR
ENG-204	English-III	3(3-0)	Comp-3	ENG-156
MTH-205	Linear Algebra	3(3-0)	Comp-9	MTH-104, MTH154
PHY-201	Waves & Oscillations	3(3-0)	Found-3	PHY-101, PHY-151, MTH-154
PHY-202	Fundamentals of Magnetism	3(3-0)	Found-6	PHY-152, MTH-154, PHY-151
CSC-206	Introduction to Programming for Physicists	3(3-0)	(GRF-III)	CSC-105
PHY-203	Lab-III	1 (0-1)	Found-8	----
ISL-207	Islamic Studies	2(2-0)	Comp-6	----
Total Credit Hours		**18**		

Semester-IV

C. Code	Courses Title	Cr. Hrs.	Remarks	PR/CR
PHY-253	Modern Physics	3(3-0)	Found-7	PHY-101, PHY-151, PHY152, PHY-202
ENG-254	English-IV	3(3-0)	Comp-4	PHY-204
MTH-255	Ordinary Differential Equations	3(3-0)	Comp-10	MTH-205
PHY-251	Optics	3(3-0)	Found-8	PHY-201
MAN-257	Principles of Management	3(3-0)	(GOF-II)	----
PHY-252	Lab-IV	1 (0-1)	Found-10	
Total Credit Hours		**16**		

Third Year

Semester-V

C. Code	Courses Title	Cr. Hrs.	Remarks	PR/CR
PHY-301	Mathematical Methods of Physics-I	3(3-0)	Maj-1	PHY-101, PHY-151, MTH-255, MTH-205
PHY-302	Electrodynamics-I	3(3-0)	Maj-2	PHY-152, PHY-202, MTH-154
PHY-303	Classical Mechanics – I	3(3-0)	Maj-3	PHY-101 / PHY-151
PHY-304	Electronics-I	3(3-0)	Maj-4	PHY-253
PKS-306	Pak Study	2(2-0)	Comp-5	----
PHY-305	Lab-V	2 (0-2)	Maj-17	----
Total Credit Hours		**16**		

Semester-VI

C. Code	Courses Title	Cr. Hrs.	Remarks	PR/CR
PHY-351	Mathematical Methods of Physics-II	3(3-0)	Maj-5	PHY-301
PHY-352	Quantum Mechanics-I	3(3-0)	Maj-6	PHY-253
PHY-353	Electrodynamics-II	3(3-0)	Maj-7	PHY-302
PHY-357	Classical Mechanics – II	3(3-0)	Maj-8	PHY-303
PHY-355	Statistical Mechanics	3(3-0)	Maj-9	PHY-106, MTH-154, STA-157
PHY-356	Lab-VI	2 (0-2)	Maj-18	----
Total Credit Hours		**17**		

Fourth Year

Semester-VII

C. Code	Courses Title	Cr. Hrs.	Remarks	PR/CR
PHY-401	Quantum Mechanics-II	3(3-0)	Maj-10	PHY-352
PHY-402	Atomic & Molecular Physics	3(3-0)	Maj-11	PHY-352/ PHY-401
PHY-403	Solid State Physics-I	3(3-0)	Maj-12	PHY-352, PHY-355
PHY-411	Elective - I	3(3-0)	Elective	----
PHY-406	Electronics-II	3(3-0)	Maj-13	PHY-304
PHY-405	Lab-VII	2 (0-2)	Maj-19	----
Total Credit Hours		**17**		

Semester-VIII

C. Code	Courses Title	Cr. Hrs.	Remarks	PR/CR
PHY-452	Nuclear Physics	3(3-0)	Maj-14	PHY-253
PHY-45*	Elective - II	3(3-0)	Elective	----
PHY-45*	Elective – III	3(3-0)	Elective	----
PHY-451	Solid State Physics-II	3(3-0)	Maj-15	PHY-403
PHY-45*	Elective-IV	3(3-0)	Elective	----
PHY-499	Research Project/Elective - V	3(3-0)	Maj-16	----
Total Credit Hours		**18**		

Note: Elective Course in (PHY-499) Means Physics Major Course
Minimum Degree Credit Hours= 138

Marks Breakdown for BS-Physics

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

Marks Breakdown for BS-Physics Labs (I- VII)

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

Annexure B

COMPULSORY COURSES IN BS PHYSICS (4 YEAR)

ENGLISH-I
Credit Hours: **3(3-0)**
Course Code: **ENG-103**

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.

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-156**
Pre-Requisite: **ENG-103**

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.

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-204**
Pre-Requisite: **ENG-156**

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-254**
Pre-Requisite: **ENG-156**

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-207**

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 Selected 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-306**
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.

INTRODUCTION TO COMPUTING

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

Course Code: **CSC-105**

Objectives:
1. To help students gain a general understanding of the principles and concepts governing the functions of operating systems;
2. To provide the students with the opportunity to get the feel of working of an operating system through implementation of its basic functions;
3. To acquaint students with the layered approach that makes design, implementation and operation of the complex OS possible

Learning Outcomes:
After studying this course the students will have fundamental concepts of computer, operating systems, and internet.

Week 1: Basic Definitions & Concepts
Week 2: Hardware: Computer Systems & Components
Week 3: Storage Devices
Week 4-5: Number Systems
Week 6: Software: Operating Systems
Week 7: Introduction to Programming
Week 8: Programming and Application Software
Week 9: Databases and Information Systems
Week 10-11: Networks and Data Communication
Week 12: The Internet, Browsers and Search Engines
Week 13: The Internet: Email, Collaborative Computing and Social Networking
Week 14: The Internet: E-Commerce
Week 15: IT Security and other issues
Week 16: Review of course

Recommended Books:
1. Introduction to Computers- Peter Norton
2. Computer Fundamentals: Pradeep K. Sinha

CALCULUS-I
Credit Hours: **3(3-0)**
Course Code: **MTH-104**
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
Pre Requisite: MTH-104
Credit Hours: 3(3-0)
Course Code: MTH-154
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: Parameterized 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
Pre-Requisite: **MTH-104, MTH-154**
Credit Hours: **3(3-0)**
Course Code: **MTH-205**
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 – eigen basis),
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. Introduction to linear algebra, Stainly Grossman

ORDINARY DIFFERENTIAL EQUATIONS

Pre-Requisite: **MTH-205**
Credit Hours: **3(3-0)**
Course Code: **MTH-255**

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 problem 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.

BASIC MATHEMATICS

Credit Hours: **3(3-0)**
Course Code: **MTH-107**

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 C

GOF / GRF COURSES FOR BS PHYSICS (4 YEAR) PROGRAM

INTRODUCTORY ECONOMICS

Credit Hours: **3(3-0)**
Course Code: **ECO-108**
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-257**

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-258

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-259**

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; 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.

STATISTICS-I

Credit Hours: 3(3-0)

Course Code: STA-157

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-155**

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
Pre-Requisite: **CSC-105**
Credit Hours: **3(3-0)**
Course Code: **CSC-206**

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.

Annexure D

FOUNDATION COURSES OF CURRICULUM BS PHYSICS (4 YEARS) PROGRAM

MECHANICS-I

Credit Hours: 2(2-0)
Course Code: PHY-101

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

Week 2: Scalars and Vectors, Adding Vectors: Graphical as well as Component Method,

Week 3: Multiplying Vectors: Dot and Cross Products.

Week 4: Motion in One, Two and Three Dimensions: Position & Displacement, Velocity and Acceleration,

Week 5: Motion under Constant Acceleration, Projectile Motion.

Week 6: Uniform Circular Motion, Relative Velocity and Acceleration in One and Two Dimensions, Inertial and Non-Inertial reference frames.

Week 7: Newton's Laws: Newton's Laws of Motion and their Applications involving some particular forces including Weight.

Week 8: Normal Force, Tension, Friction, and Centripetal Force, Newton's Law of Gravitation,

Week 9: Gravitational Potential Energy, Escape Velocity,

Week 10: Kepler's Laws, Satellite Orbits & Energy.

Week 11: Work and Kinetic Energy: Work done by Constant and Variable Forces: Gravitational and Spring Forces

Week 12: Power, Conservative and Non-conservative Forces, Work and Potential Energy

Week 13: Isolated Systems and Conservation of Mechanical Energy, Work Done by External Forces including Friction and Conservation of Energy.

Week 14: System of Particles, Motion of a System of Particles and Extended Rigid Bodies

Week 15: Center of Mass and Newton's Laws for a System of Particles.

Week 16: Linear Momentum, Impulse, Momentum & Kinetic Energy in One and Two-Dimensional Elastic and Inelastic Collisions.

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.

MECHANICS-II

Pre-Requisites: **PHY101**

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

Course Code: **PHY-151**

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: Rotational Motion, Rotation about a Fixed Axis

Week 2: Angular Position, Angular Displacement

Week 3: Angular Velocity and Angular Acceleration, Rotation under Constant Angular Acceleration

Week 4: Relationship between Linear and Angular Variables

Week 5: Rotational Inertia, Parallel-axis Theorem, Torque and Newton's Law for Rotation

Week 6: Work and Rotational Kinetic Energy, Power, Rolling Motion

Week 7: Angular Momentum for a single Particle and a System of Particles

Week 8: Conservation of Angular Momentum Precession of a Gyroscope.

Week 9: Static Equilibrium involving Forces and Torques

Week 10: Determination of moment of inertia of various shapes i.e. for disc, bar and solid sphere.

Week 11: Angular Momentum, Angular Velocity, Conservation of angular momentum

Week 12: Effects of Torque and its relation with angular momentum.

Week 13: Simple Harmonic Motion (SHM): Amplitude, Phase, Angular Frequency

Week 14: Velocity and Acceleration in SHM, Linear and Angular Simple Harmonic Oscillators

Week 15: Energy in SHM, Simple Pendulum, Physical Pendulum

Week 16: 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.

WAVES AND OSCILLATIONS

Pre-requisites: **PHY-101, PHY-151, MTH-154**
Credit Hours: **3(3-0)**
Course Code: **PHY-201**
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.

HEAT AND THERMODYNAMICS

Co-Requisite: ----
Credit Hours: 3(3-0)
Course Code: PHY-106

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.

FUNDAMENTALS OF ELECTRICITY

Pre-requisite:	**PHY-101, MTH-104**
Co-requisite:	**MTH-154, PHY-151**
Credit Hours:	**2(2-0)**
Course Code:	**PHY-152**

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
Week 2: Electric Fields due to a Point Charge and an Electric Dipole, Electric Field due to a Charge Distribution
Week 3: Electric Dipole in an Electric Field, Electric Flux
Week 4: Gauss' Law and its Applications in Planar, Spherical and Cylindrical Symmetry.
Week 5: Electric Potential, Equipotential Surfaces, Potential due to a Point Charge and a Group of Point Charges
Week 6: Potential due to an Electric Dipole, Potential due to a Charge Distribution, Relation between Electric Field and Electric Potential Energy.
Week 7: Capacitors and Capacitance, Parallel Plate, Cylindrical and Spherical capacitors

Week 8: Capacitors in Series and Parallel, Energy Stored in an Electric Field
Week 9: Dielectrics and Gauss' Law
Week 10: DC Circuits, Electric Current and Current Density
Week 11: Resistance and Resistivity, Ohm's Law
Week 12: Power in Electric Circuits, Semiconductors and Superconductors
Week 13: Work, Energy, and EMF
Week 14: Resistances in Series and Parallel
Week 15: Single and Multi-loop Circuits, Kirchhoff's Rules
Week 16: RC Circuits, Charging and Discharging of a Capacitor.

Recommended Text Books:

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.

FUNDAMENTALS OF MAGNETISM

Pre-requisite:	**PHY-152, MTH-154, PHY-151**
Credit Hours:	**3(3-0)**
Course Code:	**PHY-202**

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: Magnetic Field and Magnetic Force, Crossed Electric and Magnetic Fields and their Applications
Week 2: Hall Effect, Magnetic Force on a Current Carrying Wire, Torque on a Current Loop,
Week 3: Magnetic Dipole Moment, Magnetic Field Due to a Current

Week 4: Force between two Parallel Currents
Week 5: Ampere's Law, Biot-Savart Law: Magnetic Field due to a Current long Straight Wire carrying Current
Week 6: Magnetic Field due to Solenoids and Toroids
Week 7: A current-carrying Coil as a Magnetic Dipole, Inductance, Faraday's Law of Induction
Week 8: Lenz's Law, Induction and Energy Transfers, Induced Electric Fields
Week 9: Inductors and Inductances, Self-Inductance,
Week 10: RL Circuits, Energy Stored in a Magnetic Field
Week 11: Energy Density, Mutual Induction.
Week 12: LC Oscillations, Damped Oscillations in an RLC circuit, Alternating Currents
Week 13: Forced Oscillations, Resistive, Capacitive, and Inductive Loads
Week 14: RLC series Circuit, Power in AC Circuits, Transformers
Week 15: Gauss' Law for Magnetism, Induced Magnetic Fields Displacement Current, Spin & Orbital Magnetic Dipole Moment
Week 16: 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.

MODERN PHYSICS

Pre-requisites: **PHY-101, PHY-151, PHY152, PHY-202**
Credit Hours: **3(3-0)**
Course Code: **PHY-253**
Objective(s):
To understand the non-classical aspects of Physics, the emphasis is on the applications of Quantum 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: How crystals are different from amorphous solids.
Week 9: Why and how do metals conduct electricity. Introduction to Nuclear Structure. Radii, Isotopes, etc
Week 10: From Atoms to Molecules and Solids: Ionic bonds, covalent bonds, hydrogen bonds
Week 11-12: Molecular orbitals, Bands in solids, semiconductors, introduction to LED's and lasers, introducing grapheme.
Week 13-14: Introduction to Quantum Mechanics, The concept of a wave function, time independent Schrodinger equation and interpretation of the equation
Week 15-16: solving the Schrodinger equation for a free particle, for a particle inside an infinite box, relationship between confinement and quantization.

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: **PHY-201**
Credit Hours: **3(3-0)**
Course Code: **PHY-251**

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
Week 2: Propagation of Light, Image Formation, Huygens' Principle, Fermat's Principle
Week 3: Laws of Reflection and Refraction, Total internal reflection, Refraction at a Spherical Surface
Week 4: Thin Lenses, Newtonian Equation for a Thin Lens, Maxwell's equations
Week 5: Energy density, Momentum, Polarization, Stokes parameters, Jones vector
Week 6: EM wave propagation in conducting medium, Reflection and transmission
Week 7: Fresenel formulae, Polarization by reflection,
Week 8: Reflection from conducting surface, Interference of wave,
Week 9: Michelson interferometer, Fabry-Perot interferometer
Week 10: Ekional equation, Fermat principle and applications, lens design and matrix algebra
Week 11: Geometrical optics of resonator, Guided waves
Week 12: Optical fibre, Propagation of waves in graded index optical fibre
Week 13: Fourier series, Fourier integral, Rectangular pulse
Week 14: Pulse modulation
Week 15: Dirac delta function, Correlation
Week 16: Convolution, Gaussian beams

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.

Annexure E

MAJOR COURSES OF CURRICULUM BS PHYSICS (4 YEARS) PROGRAM

MATHEMATICAL METHODS OF PHYSICS-I
Pre-requisite: PHY-101, PHY-151, MTH-255, MTH-205
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: Review of vectors, coordinate systems, types of rectangular
Coordinate systems
Week 2: plane polar coordinates, circular cylindrical coordinates, spherical coordinates
Week 3: vector algebra, transformation of vectors, dot and cross products, triple scalar and vector products
Week 4: differentiation of vectors fields, gradients, divergence and curl of vector fields
Week 5: vector identities, Levi-Civita Symbol, vector integration, Gauss's theorem, Green's theorem in plane
Week 6: Stokes's theorem. Kronecker and Dirac Delta Functions.
Week 7: Complex Analysis, Review (polar form of complex numbers and de Moivre's theorem, complex logarithms and powers),
Week 8: functions of a complex variable, Cauchy-Riemann conditions, power series in a complex variable and analytic continuation with examples
Week 9: Multi-valued functions and branch cuts, singularities and zeroes of complex functions, complex integration
Week 10: Cauchy's theorem, Cauchy's integral formula, Laurent series and residues
Week 11: Residue integration theorem, definite integrals using contour integration.
Week 12: Linear vector spaces, Linear Dependence of Vectors
Week 13: determinants, matrices, Algebra of matrices
Week 14: orthogonal matrices, orthogonalization, Gram-Schmidt orthogonalization
Week 15: Hermitian matrices, eigenvalues and eigenvectors of matrices
Week 16: diagonalization of matrices, Hilbert space

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.
4 Vector analysis, by Murray Spiegel. McGraw Hill

ELECTRODYNAMICS-I

Pre-requisites: **PHY-152, PHY-202, MTH-154**
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: Vector analysis: Vector addition and multiplication, Scalar and vector triple products, Position, displacement and separation vectors, Differential Calculus: Gradient, Divergence, Curl, Product rules
Week 2: Integral Calculus: Line, surface and Volume integrals, The fundamental theorems of calculus (gradient, divergence, and curl),
Week 3: Curvilinear coordinates: Spherical polar coordinates, cylindrical coordinates, The Dirac delta function
Week 4: Electrostatics: Introduction, Coulomb’s law, The electric field, The superposition principle, Continuous charge distributions,
Week 5: The divergence of the electric field, Gauss’s law, Applications of Gauss’s law, The curl of the electric field,
Week 6: The electric potential, comments on the electric potential, Poisson’s and Laplace’s equation, The electric potential of a localized Charge distribution
Week 7: Electrostatic boundary conditions, Work and energy in electrostatics, The energy of a point charge distribution,
Week 8: The electric potential energy of a continuous charge distribution, Comments on electrostatics energy, Conductors and its properties, Induced charges,
Week 9: Special techniques: Laplace’s equation in 1, 2 and 3-dimensions, Boundary conditions and uniqueness theorems,
Week 10: Separation of variable technique in Cartesian coordinates,
Week 11: Separation of variables technique in spherical coordinates with azimuthal symmetry,
Week 12: Multipole expansion, Approximate potentials at large distances, Monopole and Dipole terms
Week 13: Origin of coordinates in multipole expansions, The electric field of a dipole
Week 14: Electric fields in Matter: Dielectrics, Induced dipoles, Alignment of polar molecules,
Week 15: Polarization, The field of Polarized object, Bound charges and their physical interpretation,

Week 16: The field inside a dielectric, The electric displacement, Gauss's law in the presence of Dielectrics, A deceptive parallel, Boundary conditions, Linear dielectrics

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-I

Pre-requisites: **PHY101, PHY151**
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 1-2: Review of Newtonian Mechanics,
Week 3-4: Frame of reference, Galilean transformation, orthogonal transformations, Angular velocity and angular acceleration,
Week 5-6: conservation laws, motion of single particle, motion of systems of particles, motion under a constant force, motion under variable force, time-varying mass system.
Week 7-9: Central Force Motion, The two-body problem, effective potential and classification of orbits,
Week 10-12: Kepler's laws, Stability of circular orbits, hyperbolic orbits and Rutherford scattering,
Week 13-14: Center of mass co-ordinate system, scattering cross-sections, Motion in Non-inertial Systems
Week 15-16: Accelerated translational co-ordinate system, Dynamics in rotating co-ordinate system, motion of a particle near the surface of the earth

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: **PHY-253**
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: 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 15-16: Operational Amplifiers, The integrated amplifier, the differential amplifier, Common mode rejection ratio, the operational amplifier.

Recommended Books:

1. Thomas L. Floyd, "Electronics Fundamentals: Circuits, Devices and Applications", Prentice Hall, 8th ed., 2009.

1. 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: **PHY-301**
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: Introduction to tensor, covariant and contra-variant Tensors, tensor algebra, contraction, direct product, summation convention, quotient rule.

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: **PHY-253**
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: Wave Function, State of a system, observables and operators, Measurement in quantum mechanics
Week 2: The state function and expectation values, the time development of the state function, solution to the initial-value problem in quantum mechanics
Week 3: Particle in a box, the state of a system and its normalization, Dirac notation of the state
Week 4: Hilbert Space and its properties, Hermitian Operators, Hermitian Adjoint, properties of Hermitian operators
Week 5: The superposition principle, Hilbert-Space Interpretation, the initial square wave
Week 6: the chopped beam, superposition and uncertainty, commutator relations in quantum mechanics
Week 7: commutator theorem, commutator relations and the uncertainty principle
Week 8: Time Development of State Functions, the discrete and continuous cases
Week 9: Free-Particle Propagator, distortion of the Gaussian State in Time, Flattening of the delta function
Week 10: Time Development of Expectation Values, Ehrenfest's Principle
Week 11: Conservation of Energy, Linear and Angular Momentum, Conservation of Parity.
Week 12: General Properties of one-dimensional Schroedinger's Equation
Week 13: The Harmonic Oscillator, Annihilation and Creation Operators
Week 14: Eigenfunctions of the Harmonic Oscillator Hamiltonian, The Harmonic Oscillator in Momentum Space
Week 15: Unbound States, Continuity Equation, Transmission and Reflection Coefficients, One-Dimensional Barrier Problems
Week 16: The rectangular barrier tunneling, the Ramsauer Effect, Kinetic Properties of a Wave Packet Scattered from a Potential Barrier

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: **PHY-302**

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.

Week 1: Magnetostatics: Magnetic fields and forces, The Lorentz force law, currents and current densities

Week 2: The Biot-Savart law, The magnetic field of a steady current, The divergence and curl of of magnetic field,

Week 3: Ampère's law and its applications

Week 4: Comparison of electrostatics and magnetostatics, Magnetic vector potential, The vector potential,

Week 5: Summary and magnetostatic boundary conditions, Multipole expansion of the magnetic vector potential,

Week 6: Magnetic fields in matter: Magnetization, Diamagnets, Paramagnets, Ferromagnets, Torques and forces on magnetic dipoles,

Week 7: Effect of magnetic field on atomic orbits, Magnetization, The field of magnetized object, Bound currents and its physical interpretation,

Week 8: The Auxiliary Field, Ampère's law in magnetized materials, A deceptive parallel, Boundary conditions,

Week 9: Linear and non-linear media, Magnetic susceptibility and permeability, Ferromagnetism,

Week 10: Electrodynamics: Ohm's law, Electromotive force, Motionla emf, Electromagnetic induction, Faraday's law,

Week 11: The induced electric field, inductance,

Week 12: Energy in magnetic fields, Electrodynamics before Maxwell,

Week 13: Maxwell's equations, Magnetic charge, Maxwell's equations in matter, Boundary conditions

Week 14: Conservation laws, Charge and energy, The continuity equation, Poynting's theorem,

Week 15: Newton's third law in Electrodynamics, Maxwell's stress tensor

Week 16: Conservation of momentum, Angular momentum, Propagation of electromagnetic waves

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.

CLASSICAL MECHANICS-II

Pre-requisites: **PHY-303**
Credit Hours: **3(3-0)**
Course Code: **PHY-357**

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 ideas and formulations of Classical Mechanics and its applications in various subjects of physics.

Week 1-2: The Motion of Rigid Bodies, The Euler angles,
Week 3-4: Rotational kinetic energy and angular momentum, the inertia tensor.
Week 5-6: Euler equations of motion, motion of a torque-free symmetrical top.
Week 7-8: Stability of rotational motion.
Week 9-10: The Lagrange Formulation of Mechanics and Hamilton Dynamics.
Week 11-12: Generalized co-ordinates and constraints, D'Alembert principle and Lagrange's Equations
Week 13-14: Hamilton's principle, integrals of motion, non-conservative system and generalized potential,
Week 15: Lagrange's multiplier method, the Hamiltonian of a dynamical system,
Week 16: Canonical equations, canonical transformations, Poisson brackets, phase space and Liouville's theorem.

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

STATISTICAL MECHANICS
Pre-requisites: **PHY-106, MTH-154, STA-157**
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: PHY-352
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: Basic Properties and Cartesian Components, Commutation Relations, Uncertainty Relations
Week 2: Eigenfunctions and eigenvalues of Angular Momentum operators, Ladder Operators
Week 3: Spherical Harmonics, Angular Momentum and Rotation, Legendre Polynomials
Week 4: Polar plots of $Y_{lm}(\theta, \varphi)$, Second Construction of the Spherical Harmonics, Addition of Angular Momentum
Week 5: Two Electrons case, Coupled and Uncoupled Representations, Clebsch-Gordan Coefficients.
Week 6: The Radial Equation, Centrifugal Term, Quantum Numbers, Principle quantum, Magnetic and Orbital quantum numbers
Week 7: Spherical Bessel function, Spherical Neumann function,The Radial Wave Function,
Week 8: Bohr Formula, Bohr Radius, Binding energy, Ground State, Associated Laguerre Polynomial.
Week 9: Time- Independent Nondegenerate Pertubation Theory, Smallness of the Perturbation, The Perturbation Expansion, First-Order Corrections
Week 10: Second-Order Corrections, Time- Independent, Degenerate Pertubation Theory, First-
Order Energies, The Secular Equation
Week 11: Two-Dimensional Harmonic Oscillator, The Stark Effect, The Nearly Free Electron Model, The Perturbation Potential
Week 12: Time-Dependent Pertubation Theory, Harmonic Perturbation, Stimulated Emission
Week 13: Energy-Time Uncertainty, Long-time Evolution, Short-Time Approximation, The Golden Rule.
Week 14: Partial Waves, The Rutherford Atom, Scattering Cross-section, The Scattering Amplitude,
Week 15: Partial Wave Phase Shift, Relative Magnitude of Phase Shift, The Born Approximation
Week 16: Determination of Scattering Amplitude using Born Approximation, The Shielded Coulomb Potential.

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: **PHY-352**
Co-requisite: **PHY-401**
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: Introduction, Atomic structure, atomic models
Week 2: The Rutherford scattering formula
Week 3: Electron Orbits, atomic spectra, The Bohr atom
Week 4: Energy levels and spectra, Correspondence Principle, Nuclear motion, Atomic excitation
Week 5: Review of quantum mechanics, Wave equation
Week 6: Schrödinger equation, The particle in a box, harmonic oscillator
Week 7: Schrödinger equation for Hydrogen Atom, Separation of variables
Week 8: Quantum Numbers, Principle quantum number, orbital quantum number, magnetic quantum number
Week 9: The normal Zeeman effect, Electron Probability Density, radiative transitions, Selection rules
Week 10: Electron spin, Strern-Gerlach experiment, Pauli Exclusion Principle, Periodic table
Week 11: Spin orbit coupling, Total angular momentum, LS coupling, JJ coupling, Term symbols
Week 12: X-ray spectra, Discrete X-ray spectra, Continuous X-ray Spectra, Auger effect, The Laser
Week 13: Molecular bond, Electron sharing, Hydrogen molecule
Week 14: Complex molecules, Rotational energy levels, Rotational spectra
Week 15: Vibrational energy levels, Vibrational spectra
Week 16: Electronic spectra of molecules

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: **PHY-352, PHY-355**
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: Simple crystal structure and basis crystal structure, the space lattice, basic definitions of crystallography, primitive and non-premitive unit cells, Bravais and non-Bravais lattices
Week 2: 7 crystal systems and 14 Bravais lattices and their classification, some representative crystal structures
Week 3: Atomic packing factor, Miller indices, planes and directions in crystals, Wigner-Seitz cell, Miller indices for crystallographic planes and their importance, crystal symmetries (translational, rotational, reflection etc.)
Week 4: Crystal structure analysis, X-rays and electrons can be used for crystal diffraction, difference between X-rays and electrons diffraction
Week 5: X-ray diffraction and Bragg's law, Fourier analysis (general discussion), Fourier analysis of electron number density
Week 6: The scattered wave amplitude, diffraction conditions for x-ray diffraction from crystals (for elastic and inelastic case)
Week 7: Ewald sphere/construction as a geometrical interpretation of Bragg's condition, reciprocal lattice and relation between direct and reciprocal lattice vectors
Week 8: Laue equations, Brillouin Zones, FCC in real space is BCC and vice versa, Fourier analysis of basis, structure factor and its examples, atomic form factor
Week 9: Atomic structure and crystal bonding, interatomic forces and types of atomic and molecular bonds (covalent, metallic, ionic), Van der Waals bonding, hydrogen bonding
Week 10: Lattice vibrations: phonons, average energy of phonons, the concept of energy quantization: black body radiation, phonons can be created by increasing temperature (unlike fermions), heat capacity
Week 11: specific heat capacity and molar heat capacity, some examples of heat capacity from daily life, classical model of heat capacity (Dulong and Petit law),
Week 12: Einstein's theory of specific heat capacity, Dispersion relation and density of states, Debye model for heat capacity, heat conduction
Week 13: thermal conductivity: phenomenological approach, thermal conductivity: microscopic approach, some examples of thermal conductivity from daily life
Week 14: Free electron theory of metals: concept of free electrons, neglecting electron-electron and electron-ions interaction, Ohm's law and electrical resistivity/conductivity, Drude model,

Week 15-16: Electrical resistivity versus temperature, Wiedemann-Franz law, the Hall effect and cyclotron frequency, the problem of electrons' contribution to specific heat capacity can be resolved by consulting quantum mechanics

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.

ELECTRONICS-II

Pre-requisites:	**PHY-304**
Credit Hours:	**3(3-0)**
Course Code:	**PHY-406**

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.

NUCLEAR PHYSICS

Pre-Requisites: **PHY-253**
Credit Hours: **3(3-0)**
Course Code: **PHY-452**
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.

SOLID STATE PHYSICS -II

Pre-requisites:	**PHY-403**
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: Nearly-free electron theory of metals, filling of energy levels and probability of occupation of states in Fermi gas, introduction to band theory of solids and bands formation, nearly free electron approximation
Week 2: The Bloch theorem, formation of energy bands following the concept of Bragg's diffraction condition in crystalline metals
Week 3: formation and solution of so-called central equation to verify the concept of band gaps, Tight-binding approximation

Week 4: The de Haas-van alphen effect, free electron in a uniform magnetic field, Levels of Bloch electron in a uniform magnetic field, defects in crystals: crystal imperfections, thermodynamics of point defects
Week 5: Schottky and Frenkel defects, color centres, dislocations in solids, Burgers vectors, edge dislocation, screw dislocation, slip and plastic deformation
Week 6: Stacking faults and grain boundaries, strength of crystals, diffusion and Fick's law, Semiconductors - an introduction, intrinsic semiconductors, extrinsic semiconductors, Energy band structure
Week 7: Donor and acceptor levels, calculation of number of electrons and number of holes and law of mass action
Week 8: Superconductivity - an introduction, zero resistivity and Meissner effect, type-I and type-II superconductors,
Week 9: BCS theory, electron-phonon-electron interaction via lattice deformation, ground state of superconductors, Cooper pairs, coherence length
Week 10: London equations (electrodynamics), London penetration depth, thermodynamics of superconductors, entropy and the Gibbs free energy,
Week 11: Josephson effect, superconductors applications, The History, applications and revolution in society due to magnetism, anology between electric and magnetic fields, calculation of magnetic fields
Week 12: atomic theory of magnetism, paramagnetism, Langevin theory of paramagnetism,
Week 13: Ferro-magnetism, Weiss theory of ferromagnetism (spontaneous magnetization), magnetic domains, domain walls, domain wall energy and thickness, magnetic relaxation and resonance phenomena
Week 14: Dielectrics and Ferroelectrics: Maxwell equations, polarization, dielectric constant and dielectric polarizability, electrical susceptibility
Week 15: Clausius-Mossotti relation, structural phase, transitions, ferroelectric crystals, classification of ferroelectric crystals, theory of ferroelectric displacive transitions
Week 16: thermodynamic theory of ferroelectric transition, ferroelectric crystals, ferroelectric domains, piezoelectricity

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.

Annexure F

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)
1.	Plasma Physics	3(3-0)	PHY-411	PHY-201, PHY-353
2.	Electronic Materials and Devices	3(3-0)	PHY-461	PHY-251, PHY-304
3.	Materials Science	3(3-0)	PHY-462	PHY-403
4.	Nano Science and Nanotechnologies	3(3-0)	PHY-463	PHY-451, PHY-401
5.	Introduction to Special Relativity	3(3-0)	PHY-464	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
9.	Quantum Information and Quantum Computation	3(3-0)	PHY-468	PHY-352
10.	Quantum Field Theory	3(3-0)	PHY-469	PHY-401
11.	Lasers	3(3-0)	PHY-470	PHY-401, PHY-402
12.	Experimental Techniques in Particle and Nuclear Physics	3(3-0)	PHY-471	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
15.	Introductory Particle Physics	3(3-0)	PHY-474	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
18.	Computational Physics	3(3-0)	PHY-477	----
19.	Clay Science	3(3-0)	PHY-478	PHY-403

PLASMA PHYSICS

Pre-requisite: PHY-353, PHY-201
Credit Hours: 3(3-0)
Course Code: PHY-411

Objective(s):
1. To understand about the importance of the plasma
2. To understand the basic concepts of plasma

Learning Outcomes:
After studying this course the students will learn about the dynamics of charged particles in 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: **PHY-304, PHY-251**
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: Review of Number Systems: Binary, Octal and Hexadecimal number system, their inter-conversion
Week 2: Concepts of logic, truth table, basic logic gates
Week 3-5: Boolean algebra: De Morgan's theorem, simplification of Boolean expression by Boolean Postulates and theorem, K-maps and their uses.
Week 6-7: Combinational Logic Circuit: Logic circuits based on AND – OR, OR-AND, NAND, NOR Logic
Week 8: Semiconductor Fundamentals, Composition, purity and structure of semiconductors, energy band model
Week 9: Band gap and materials classification, charge, effective mass and carrier numbers, density of states
Week 10: Device Fabrication Processes: Oxidation, diffusion, ion implantation, lithography
Week 11-12: Thin-film deposition techniques like evaporation, sputtering, chemical vapour deposition (CVD), epitaxy etc.
Week 13-14: Optoelectronic Devices: Photoconductors, photovoltaics and photodetectors, photodiodes and photovoltaics
Week 15-16: solar cell basics, LEDs, Lasers, displays, LCDs.

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.
5. D. Jiles, "Introduction to Magnetism and Magnetic Materials", Chapman & Hall, 2nd ed. 1998.

MATERIALS SCIENCE

Pre-requisites: **PHY-403**
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/

NANO SCIENCE AND NANOTECHNOLOGIES

Pre-requisite: **PHY-451, PHY-401**
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.

INTRODUCTION TO SPECIAL RELATIVITY

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

Course Code: **PHY-465**

Objectives: To introduce the students with concepts of special theory of relativity.

Learning Outcomes: The students will learn Physics about frames of reference, transformations and relativistic effects.

Week 1-2: Introduction and relativity pre-Einstein, Einstein's principle of relativity and a new concept of spacetime, The great kinematic consequences of relativity,Velocity addition and other differential transformations, V Kinematics and "Paradoxes" Relativistic momentum and energy, Basics Relativistic momentum and energy, Four vectors and transformation properties General relativity: Einstein's theory of gravity

Week 3-4: Intuition and familiarity in physical law. Relativity before Einstein,Inertial frames, Galilean relativity, Form invariance of Newton's Laws,Galilean transformation, Non-inertial frames, Galilean velocity addition

Week 5-6: Electromagnetism, light and absolute motion. Particle and wave interpretations of light, Measurement of c, Maxwell's theory → electromagnetic waves, Maxwell waves ↔ light. Search for the aether, Properties of the aether, Michelson-Morley experiment

Week 7-8: Precursors of Einstein, Lorentz and Poincar´e, Lorentz contraction, Lorentz invariance of electromagnetism, Principles of relativity, Postulates, Resolution of Michelson-Morley experiment, Need for a transformation of time. Intertial systems, clock and meter sticks, reconsidered. Setting up a frame, Synchronization, Infinite family of inertial frames

Week 9-10: Lorentz transformation, The need for a transformation between inertial frames, Derivation of the Lorentz transformation, Immediate consequences, Relativity of simultaneity, Spacetime, world lines, events, Lorentz transformation of events, Algebra of Lorentz transformations, β, γ, and the rapidity, η. Analogy to rotations
Inverse Lorentz transformation.

Week 11-12: Length contraction, Proper length, Careful measurements of length → length contraction, Is length contraction real? Time dilation, Proper time, Careful measurements of duration → time dilation, Is time dilation real? Time dilation as a measured phenomenon, Duality between length contraction and time dilation, Intervals, causality, etc.

Week 13-14: Invariance of the interval under Lorentz transformation, Spacelike, timelike, and lightlike intervals, Causality: the Future, the Past, and Elsewhere, Minkowski space and coordinate systems

Week 15-16: Differential form of the Lorentz transformation, Addition of velocities, The transformation: parallel and perpendicular, Examples: relative velocities, Transformation of angles, Static angles: transforming geometry, Dynamical angles: transforming rectilinear motion, Relativistic aberration.

Recommended Texts:

1. Resnick, Robert. *Introduction to Special Relativity.* New York, NY: Wiley, 1968. ISBN: 9780471717256.
2. French, Anthony Philip. *Special Relativity.* New York, NY: Norton, 1968. ISBN: 9780393097931.
3. Einstein, Albert A. *Relativity: The Special and the General Theory.* New York, NY: Three Rivers Press/Random House, 1995. ISBN: 9780517884416.
4. Rindler, Wolfgang. *Essential Relativity.* 2nd ed. Springer-Verlag. ISBN: 9780387100906. (A more advanced book.)
5. Sciama, Dennis W. *The Physical Foundations of General Relativity.* Doubleday-Anchor, 1969. No ISBN number.
6. Sartori, Leo. *Understanding Relativity.* University of California Press, 1996. ISBN: 9780520079861.

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: **PHY-352, PHY-477**
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 AND QUANTUM COMPUTATION

Pre-requisites: **PHY-352**
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 1-3: Computer technology and historical background; Basic principles and postulates of quantum mechanics: Qubits and Quantum states, Matrices and operators, tensor product, quantum measurement
Week 4-6: superposition, quantization from bits to qubits, operator function, The density operators, Schrodinger equation, Schmidt decomposition, EPR and Bell's inequality; Quantum Computation
Week 7-9: Quantum Measurement theory, Quantum entanglement theory, entanglement teleportation, Quantum gates and Circuits, Controlled operations, Breaking unbreakable codes: Code making
Week 10-12: Trapdoor function, One time pad, Quantum Cryptography, RSA cryptography, Code breaking on classical and quantum computers, Shor's algorithm; Uncertainty principle, Polarization and Spin basis, BB84, BB90
Week 13-14: Ekert protocols, Quantum cryptography with and without eavesdropping, Experimental realization
Week 15-16: Quantum Search Algorithm, Quantum Noise and error correction, Tools of Quantum information theory.

Recommended Texts:

1) Quantum Computation and Quantum Information by M. A. Nielson and I. L. Chuang, Cambridge University Press, Cambridge 2000.
2) Exploration in Quantum Computation by C.P. Williams and S. H. Clearwater, Springer Verlag (1997).
3) Quantum Computing latest edition by David McMahon
4) Quantum Computation by P. Bouwmester, A. Ekert, and A. Zeilinger, Springer Verlag, Berlin, Heidelberg (2000).
5) Mathematics of Quantum Computation by A.K.Brylinsky and G. Chen, Chapman & Hall/CRC (2002).
6) Principle of Quantum Computation and information latest edition by Giuliano Benenti, Giulio Casati, Giuliano Strini, Volume-1 and volume-2.

QUANTUM FIELD THEORY

Pre-requisites: **PHY-401**
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:	**PHY-401, PHY-402**
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: **PHY-474, PHY-452**
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: **PHY-101, PHY-151, MTH-104, MTH-154**
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: PHY-201, PHY-251, MTH-205, PHY-304
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.

INTRODUCTORY PARTICLE PHYSICS

Pre-requisites: PHY-401, PHY-452
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: **MTH-154, MTH-205, MTH-255, CSC-105, PHY-101, PHY-151**
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: **PHY-451**
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: **PHY-403**
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

Recommended Books:
1. F Bergaya, BKG Theng and G Lagaly, "Development in clay Science, 1, Handbook of clay Science", Elsever Ltd, 2006.
Reference books:
2. SW Bailey, "Volume 19: Hydrous Phyllosilicates (exclusive mics)", Mineralogical Society of America, 1988.
3. A K Chakarborty, "Phase Transformation of kaolinite clay", Springer India 2014.
4. V.S. Ramachandran, Ralph M. Paroli, James J. Beaudoin, and Ana H. Delgado, "Handbook of Thermal Analysis of Construction Materials", Noyes Publications, 2002.

RENEWABLE ENERGY SOURCES

Pre-requisite: **None**
Credit Hours: **3(3-0)**
Course Code: **PHY-479**

Objective(s):
At the successful completion of the course the student is expected to be able to
List and generally explain the main sources of energy and their primary applications
Describe the challenges and problems associated with the use of various energy sources, including fossil fuels, with regard to future supply and the environment.
Discuss remedies/potential solutions to the supply and environmental issues associated with fossil fuels and other energy resources
List and describe the primary renewable energy resources and technologies.
Learning Outcomes:
This course provides an introduction to energy systems and renewable energy resources, with a scientific examination of the energy field and an emphasis on alternate energy sources and their technology and application. The class will explore society's present needs and future energy demands, examine conventional energy sources and systems, including fossil fuels and nuclear energy, and then focus on alternate, renewable energy sources such as solar, biomass (conversions), wind power, geothermal, and hydro. Energy conservation methods will be emphasized.

Week 1: Energy Scenarios:Importance of energy, world primary energy sources, Energy demand, supplies, reserves, growth in demand, Life estimates, and consumption pattern of conventional energy sources: oil, gas, coal, hydro, nuclear etc.

Week 2: Energy & Environment:Emission of pollutants from fossil fuels and their damaging effects and economics impact, Renewable energy and its sustainability

Week 3: Renewable Scenarios:Defining renewable, promising renewable energy sources, their potential, availability, present status, Existing technologies and availability

Week 4: Solar Energy: Sun-Earth relationship, geometry, sun path and solar irradiance, solar spectrum, solar constant, Atmospheric effects, global distribution, daily and seasonal variations, Effects of tilt angle, resource estimation, extraterrestrial, global, direct, diffused radiation

Week 5: Sun shine hours, air mass, hourly, monthly and annual mean, radiation on tilt surface, measuring instruments, Solar Thermal:Flat plate collectors, their designs, heat transfer, transmission through glass,

Week 6: Absorption and transmission of sun energy, selective surfaces, performance, and efficiency, Low temperature applications: water heating, cooking, drying, desalination, their designs and performance

Week 7: Concentrators, their designs, power generation, performance and problems, Photovoltaic:PV effect, materials, solar cell working, efficiencies, Different types of solar cells, characteristics, (dark, under illumination), Efficiency limiting factors, power, spectral response, fill-factor, temperature effect

Week 8: PV systems, components, packing fraction, modules, arrays, controllers, inverters, storage, PV system sizing, designing, performance and applications

Week 9: Wind: Global distribution, resource assessment, wind speed, height and topographic effects, Power extraction for wind energy conversion, wind mills, their types, capacity, properties, Wind mills for water lifting and power generation, environmental effect

Week 10: Hydropower: Global resources, and their assessment, classification, micro, mini, small and large resources, Principles of energy conversion, Turbines, types, their working and efficiency for micro to small power systems, Environmental impact, Biogas: Biomass sources; residue, farms, forest. Solid wastes, Agricultural, industrial and municipal wastes etc

Week 11: Utilization process, gasification, digester, types, energy forming, Environment issues. Resources availability; digester, their types, sizes, and Working

Week 12: Gas production, efficiency; environmental effects, Geothermal: Temperature variation in the earth, sites, potentials, availability, extraction techniques, Waves and Tides: Wave motion, energy, potentials, sites, power extraction, and transmission

Week 13: Generation of tides, their power, global sites, power generation, resource assessment

Week 14: Hydrogen Fuel: Importance of H2 as energy carrier, Properties of H2, # production, hydrolysis, fuel cells, types

Week 15: Nuclear: Global generations of reserves through reprocessing and breeder reactors, Growth rate, prospects of nuclear fusion, safety and hazards issue

Week 16: Energy Storage, Importance of energy storage, storage systems, Mechanical, Chemical, biological, heat, electrical energy storage, fuel cells etc.

Recommended Books:

1. World Energy Supply: Resources, Technologies, Prospectives: Manfred Grathwohl; Walter deGruyter – Berlin, 1982.
2. Renewable Energy Resources; John W. Twidell and Anthony D. Weir; Routledge; 3 edition (January 14, 2015)
3. An Introduction to Solar Radiation: Muhammad Iqbal; Academic Press, Canada. 1983.
4. A Practical Guide to Solar Electricity, Simon Roberts: Prentice Hall, Inc. USA, 1991.
5. Solar Cells, Operating Principles, Technology, and system Application: Martin A. Green; Printice Hall, Inc. USA, 1982.
6. Solar Engineering Technology; Ted. J. Jansen, Prentice Hall, Inc. USA, 1985.
7. Wind Power, A. and Book on Wind Energy Conversion System; V. Daniel Hunt, Litton Educational Publishing Inc. 1981.
8. Biogas, Production and Utilization; Elizabeth C. Price, Paul N. Cheremisinoff; Ann Arbor Science, USA, 1981.

Biomass, Catalysts and liquid fuels; Ian Campbell; Technonic Publishing Co. Inc. USA, 1983.

BIO-PHYSICS

Course code: **PHY405**
Credit Hours: **3(3-0)**

Pre-requisites:

Course Description: An introduction to the physical principles that underlie the dynamics of life from the macro to molecular scale. The course is intended as an optional course for final year BS students. This course will cover a broad spectrum of topics including mechanics of human body and animals, vision and hearing of living bodies, electrical and optical properties of molecules, and applications of physics principles in medical science such as MRI etc.

Course Objectives: The objectives of this course are
to explore the biophysics of signaling and movement at the cellular level
to introduce mathematical modeling in biophysics
to appreciate how biophysical measurements can be acquired and used in clinical environments
to explore the applications of physical principles in medical physics

Week 1: Motion and Bio-dynamics, Animal Locomotion, Simple Pendulum, Comparison of Pendulum and animal's legs and stepping time for an animal

Week 2: Human legs as a Physical pendulum, the action of forces and torques, Waves and Bio-Optics

Week 3: Wave phenomenon, Properties of sound waves and hearing, structure and function of the ear,the auditory canal and resonance in a closed /opened pipe

Week 4: The middle Ear and the impedance matching between inner and outer ear, The inner Ear and resonance in Basilar fibers (Newton 2^{nd} law of motion)

Week 5:, Optics in vision and eyesight correction,Properties of light refraction, reflection , Thin lenses and related concepts, Refractive power of lens

Week 6: Optics of the eye and vision, Refractive power of the eye, visual acuity, Pupillary diameter effects, Eyesight problems and correction, Light Absorption and Color in Bio-molecules
Week 7: Colors in biological tissues and natural pigments, Pigments and simple quantum mechanics, Electron resonance in a linear/cyclic conjugated molecules
Week 8: Absorption and emission of light, Perception of colors and photoreceptors (cones), Absorption dependence on molecule length
Week 9: Vibrational spectra, Electricity and Conduction in Human Body: Neurons and Nerve conduction, Electrical properties of Neurons, the concepts of resistance and voltage
Week 10: Ohm's law, capacitance, interpretation of impulse propagation, Electric Potential and membrane Potential, electrical circuits and cardiovascular system, Action potential, Ohm's law, cable model of Axon, RC components and Axon membrane
Week 11: Bio-Imaging: Protein structures, X-ray crystallography, and Bragg's law, Nuclear magnetic resonance (NMR) spectroscopy, Magnetic resonance imaging (MRI),Intrinsic magnetism and angular momentum effects, chemical shift and NMR Microscopy
Week 12: Ultrasound imaging, Tomography or X-rays computed axial tomography (CAT or CT scan), Positron emission tomography (PET), Thermodynamics and the Origin of Life: Body temperature regulation
Week 13: cellular metabolism,Living systems and first law of thermodynamics and energy conservation, Internal energy, Enthalpy,Life and 2nd law of thermodynamic
Week 14: Molecular entropy and disorder, Free energy of a system, Free energy and chemical equilibrium, Diffusion, Diffusion across membranes, Gibb's free energy
Week 15: Fick's law and passive diffusion across membranes, Fluid system and Human Cardiovascular system Fluid dynamics of Human circulation, The concepts of pressure and flow rate, the systemic and pulmonary systems
Week 16: The continuity equation and the relation between cross-section of the aorta and velocity of blood, Hydrostatics and the effect of viscosity flow rate of blood and poiseuille's equation, Power output and work done by the heart

Recommended Texts:

1. Philip Nelson, Biological Physics: Energy, Information, Life, W.H. Freeman & Co., New York, 2004.
2. Ronald Glaser, Biophysics, 5th edition, Springer 2001

ASTROPHYSICS

Course No.	**PHY484**
Credit Hours:	**3(3-0)**
Pre-requisite:	**None**

Course Description:
Astrophysics deals with some of the most majestic themes known to science. Among these are the evolution of the universe from the Big Bang to the present day; the origin and evolution of planets, stars, galaxies, and the elements themselves; the unity of basic physical law; and the connection between the subatomic properties of nature and the observed macroscopic universe.

Objectives: A successful student should be able to:
1. Describe the features of objects in the Solar System (i.e. Sun, planets, moons, asteroids, comets, planetary interiors, atmospheres, etc.) giving details of similarities and differences between these objects;
2. Demonstrate an understanding of the basic properties of the Sun and other stars;
3. Explain stellar evolution, including red giants, supernovas, neutron stars, pulsars, white dwarfs and black holes, using evidence and presently accepted theories;
4. Explain the evolution of the expanding Universe using concepts of the Big Bang and observational evidence;
5. Use information learned in class and develop observation skills to be able to explain astronomical features and observations obtained via telescopic observations or data provided through computer simulations.

Week 1: Introduction and overview, Telescopes, Detectors
Week 2: Instruments, Satellites, Matter and Radiation
Week 3: Interstellar medium, Collapse of gas clouds
Week 4: Jeans criterion, Star formation and Stellar structure
Week 5: Nuclear reactions, Hydrostatic equilibrium, Virial theorem, Stars masses

Week 6: Stellar atmospheres, Energy transport via radiation and convection, Atomic transitions
Week 7: chemical abundances, Properties of Stars and their spectra, Stellar dynamics, Evolution and final stages
Week 8: Phenomenology of stars, Magnitudes, colors, spectra, Distances
Week 9: radii, temperatures and luminosities, Binaries, Gravitational time scale
Week 10: Thermal and nuclear time scales. Ages of star, Metallicities, Evolution on the Main Sequence, Stellar evolution beyond the main sequence
Week 11: AGB stars, HR Diagram, Binary Stars and Accretion Processes, Fate of Massive Stars
Week 12: Supernova, types of supernova, Degenerate matter
Week 13: Stellar remnants, White dwarfs
Week 14: Brown Dwarf, Neutron stars and black holes
Week 15: Pulsars, gamma-ray bursts, Planetary Nebulae
Week 16: X-ray binaries ,Presentations

Recommended Texts:
1. An Introduction to Modern Stellar Astrophysics, D.A. Ostlie, B.W. Carrol, Addison-Wisley Publishing Company, Inc., 1996.
2. Nucleosynthesis and Chemical Evolution of Galaxies, B.E.J. Pagel, Cambridge Uni. Press, 1997.

COSMOLOGY

Course Code	**PHY425**
Credit Hours:	**3(3-0)**
Pre-requisite (s)	**None**

Course description:

We will apply the laws of physics to address some fundamental questions: What are our origins? What is our place in the overall cosmic scene? What is time? What is dark energy, and what the dark matter? Cosmology has recently made great strides, primarily driven by novel telescopes and other observational probes. We will trace this great story of discovery, leading us to the current frontier of knowledge. You will learn to look at the physics behind these exciting phenomena, and make things as simple as possible, but still capture the important effects.

Objectives:

1. To understand the basics of the subject
2. To learn about inflation and dark energy
3. To be able to appreciate difficulties with Newtonian gravitation
4. To be able to understand the theory of expansion of universe
5. To understand the theory of inflation

Week 1: Introduction, Background of Cosmology, Newtonian cosmology
Week 2: Cosmological redshift, Hubble's law, Microwave Background
Week 3: The Big Bang expansion rate, The Cosmic Microwave Background Radiation (CMBR)
Week 4: Radiation domination, History of the universe, Isotropy, Homogeneity
Week 5: Clustering properties of galaxies and large-scale structure, Friedmann equation, Difficulties with Newtonian gravitation
Week 6: Mach's Principle, Robertson-Walker metric, Dark matter
Week 7: Nucleosynthesis, The Early Universe, Inflation, The very early universe, Dark matter

Week 8: Cosmological Principles, Measurements of distances, luminosities, angular sizes, etc. in the cosmological context
Week 9: The Friedman models of classical cosmology, Observational tests of the Friedman models
Week 10: The Anthropic Principle and Dirac's large numbers, Radiation-dominated expansion
The epoch of "recombination", Nuclear statistical equilibrium in the early Universe
Week 11: Synthesis of the light elements, Measurements of primordial light element abundances
Week 12: Baryon and lepton asymmetry in the early Universe, Equation of state for inflation
Week 13: Fluctuation spectrum emerging from the inflationary epoch, Jeans' instability
Week 14: Growth of density perturbations in Friedman models, Dissipation processes
Week 15: Adiabatic and isothermal fluctuations in baryonic matter, Growth of fluctuations and damping processes in non-baryonic matter
Week 16: Gravitational, adiabatic, and Doppler perturbations,Multipole expansion of temperature fluctuations, Non-linear collapse of density perturbations

Recommended Texts:

1. J. V. Narlikar, Introduction to Cosmology, Cambridge University Press, 1989.
2. Peter Coles *Cosmology: A Very Short Introduction*, Oxford University Press, 2001.
3. Fred C. Adams and Greg Laughlin *The Five Ages of the Universe*, Simon & Schuster, 2000,
4. Barbara Ryden, Introduction to Cosmology, Addison-Wesley; 1 edition (October 18, 2002)

STRING THEORY

Course code	**PHY422**
Credit Hours:	**3(3-0)**
Pre-requisite	**None**

Course Description:

This course introduces string theory to undergraduate. Since string theory is quantum mechanics of a relativistic string, the foundations of the subject can be explained to students exposed to both special relativity and basic quantum mechanics. This course develops the aspects of string theory and makes it accessible to students familiar with basic electromagnetism and statistical mechanics.

Objectives:

1. To understand the shortcomings of the standard model
2. To understand the idea of strings as fundamental objects
3. To be able to quantize the string theory
4. To be able to extract particle content form string theory

Week 1: Introduction, Review of Basic concepts
Week 2: Special relativity, Spaces, Tensors
Week 3: Types of Tensors, Extra dimensions, Units and parameters
Week 4: Intervals, Lorentz transformations, Light-cone coordinates, Relativistic energy
Week 5: Relativistic momentum, Light-cone energy, Light-cone momentum, Lorentz invariance with extra dimensions
Week 6: Compact extra dimensions, Square well with an extra dimension, Equations of motion for transverse oscillations, Boundary conditions
Week 7: Initial conditions, Frequencies of transverse oscillation, The non-relativistic string,
Week 8: Lagrangian action for a relativistic point particle, Reparameterization invariance, Relativistic particle with electric charge
Week 9: Reparameterization invariance of the area, Area functional for space-time surfaces
Week 10: The Nambu-Goto string action, Boundary conditions, D-branes
The static gauge
Week 11: Tension of a stretched string, Energy of a stretched string,
Week 12: Action in terms of transverse velocity
Week 13: Motion of open string endpoints, String parameterization
Week 14: Classical motion, World-sheet currents, Light-cone relativistic strings

Week 15: Light-cone fields, Light-cone particles, Relativistic quantum open strings
Week 16: Relativistic quantum closed strings, Relativistic superstrings

Recommended Texts:

1. A first Course in String Theory, Barton Zwiebach, Cambridge University Press 2009
2. String Theory and M-Theory: A Modern Introduction, Katrin Becker, Melanie Becker, John H. Schwarz, Cambridge University Press, 2006
3. String Theory in a Nutshell, Elias Kiritsis, Princeton University Press, 2007
4. String Theory, Joseph Polchinski, Cambridge University Press, 1998

LITHOGRAPHY

Course Code: **PHY446**
Credit Hours: **3(3-0)**
Pre-requisite:

Course Description: Lithography is an etching process, which is different from engraving. It's easy to get the impression that printing processes begin with the actual cutting away of the slab surface. But in lithography, etching is a chemical process. The limestone or metal slab remains physically intact. The print is created by the chemical reaction that begins with the separation of oil and water. lithography was a stepping-stone toward photography. It heralded a 19th century culture of image reproduction, introducing the principles of mass production and automatic machine copying. Where once there had been the single, unique work of art, there came a slow acceptance of the many copies available circulating throughout the art market.

Week 1: Lithography (The Art), Growth of the microelectronics industry
Week 2: Device miniaturization, clean room classification
Week 3: Lithographic Strategies: Photolithography (Contact Printing, Projection Printing, Physical Limitations of Optics
Week 4: Lithographic Strategies: Image Field, Wavelength considerations, Depth of focus)
Week 5: Electron-Beam Lithography (Electron Scattering, Electron Lithography Systems, Limitations)
Week 6: X-ray Lithography, Ion-Beam Lithography and Technology Evolution
Week 7: Resist Sensitometry (Quantifying Response to Light, Quantifying Response to Ionizing Radiation
Week 8: Resist Sensitometry Quantifying Lithographic Sensitivity), Chemical Amplification
Week 9: Performance Criteria (Sensitivity and Contrast, Resolution, Line-Width Control, Defect Density, Etch Resistance)
Week 10: Processing Steps (Substrate Cleaning and Preparation, Resist Coating, Prebaking
Week 11: Exposure Post-exposure, Processing Steps Treatment, Developing,
Week 12: Plasma De-scumming, Post-baking , Etching, Stripping)
Week 13: Etching (Introduction, The Plasma State , Plasma Etching, Plasma Reactor

Week 14: Etching Dynamics, Anisotropy: Ion Etching and Chemical Etching
Week 15: Etching Wet Etching, Anisotropy in Wet Etching)
Week 16: Metallization (Introduction, Conductivity of Metals Physical Vapor Deposition)

Recommended Texts:

1. Chris A. Mack, Fundamental Principles of Optical Lithography: The Science of Microfabrication , John Wiley & Sons, (London: 2007).
2. Harry J. Levinson, Principles of Lithography, Third Edition (2011) ISBN: 9780819483249

Annexure G

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.