Department of Physics

Physics is concerned with those aspects of nature which can be understood in a fundamental way in terms of elementary principles and laws. In the opinion of a non-physicist (J Moliere, French playwright), "Physics explains the properties of natural bodies and properties of matter; it discourses on the nature of elements, minerals, plants, rocks and animals, and teaches us the causes of all the meteors, rainbow, aurora borealis, comets, lightening, thunderbolts, rains, snows, hails and whirl winds". In course of time, various specialized sciences broke away from physics to form autonomous fields of investigation. In this process physics retained its original aim of understanding the structure of the natural world and explaining natural phenomenon. Physicists think about what exists and how it works; they also seek to understand reality from possible infinite vastness of the universe down to the infinitesimal particles that form the structure of an atom.

History

The Department of Physics, University of Rajshahi, started functioning in March 1958 and its academic activity started in July 1958 in its own building in the university campus, under the leadership of Late Dr Ahmad Husain with 15 post-graduate students and three teaching staff members. The teaching was started in December, 1958. A three-year B.Sc. (Honours) course was introduced in 1962. Over the years, the department has grown in every sphere and now assumes the structure of a large department in the university.

The department has been offering a four-year B.Sc. (Honours) course since 1998. From the 2022-23 session the B.Sc. (Honours) program is being offered in a biannual semester system, rather than the previous annual system. At present, there are 25 members of teaching staff and 26 supporting technical and office staff catering the needs of over 500 students including a number of research scholars.

Location

The Department of Physics is located in the first science building, which is surrounded by the scenic beauty of the university. It has a beautiful flower garden inside.

Research Activities

The department has a long tradition of research in various areas of physics under M.Sc., M.Phil. and Ph.D. programmes. The faculty members along with their research students pursue research in diverse fields which has resulted in a large number of research publications in various journals of international repute, like Nature, Physical Review Letters, Physical Review, Nuclear Physics, Physica C, Journal of Superconductivity, Superconductor Science and Technology, Solid State Communications, Physics Letters, Journal of Materials Science, Journal of Non-Crystalline Solids, Physica Status Solidi, Journal of Physics and Chemistry of Solids, Journal of High Energy Physics, Physics and Chemistry of Glasses, Nuovo Cimento, Annals of Physics, etc. The department is also working under different international collaboration programmes with UK, USA, Japan, South Africa, Germany, India, Turkey etc. The current research areas are:

- Nuclear Physics: Nuclear Reaction and Nuclear Structure
- Materials Science
- Radiation Physics and Medical Physics

- Atomic Physics
- Condensed Matter Physics:
    - Perfect and Defect Crystals- Computer Simulation studies (theoretical).
    - Solid State Reaction (experimental)
- Superconductivity
- Semiconductors: Thin Film Deposition and Characterization
- Structural properties of Glass and Glass Ceramics
- Solar Energy
- High Energy Physics: Lattice QCD.

Teaching Activities

The department is at present involved in teaching the following courses:

- Four-year B.Sc. (Honours) degree course.
- One-year M.Sc. course in General and Thesis group.

Resources.

The department has 25 members of teaching staff consisting of Professors, Associate Professors, Assistant Professors and Lecturers, who cater the needs of nearly 500 undergraduates, post-graduates and research students. A list of members of academic staff (at time of start of physical classes) is given below:

Name	Specialization
Professor Emeritus	
Dr Arun Kumar Basak *MSc(Raj), PhD(Birmingham), FInstP (London), CPhys*	Nuclear Physics, Atomic Physics
Dr AKM Azharul Islam *MSc(Raj), PhD(London), DIC FInstP (London), CPhys*	Computational Materials Science, Superconductivity
Professors	
Dr M Mozibur Rahman (PRL) *MSc(Raj),PhD(Dnipropetrovsk, Ukraine)*	Condensed Matter Physics (Expt.), Electronics, Metallurgy
Dr M Khalilur Rahman Khan *MSc(Raj), PhD(Yamanashi, Japan)*	Condensed Matter Physics, Materials Science (Expt.), Thin films, Superconductivity
Dr Irine Banu Lucy *MSc(Raj), PhD(Brunel,UK)*	Condensed Matter Physics (Expt.)
Dr M Rafiqul Ahsan (PRL) *MSc(Raj), PhD(Raj)*	Condensed Matter Physics, Glass and Glass Ceramics, X-ray Crystallography
Dr F Nazrul Islam *MSc(Raj), PhD(Raj)*	Condensed Matter Physics (Comp. simulation), Superconductivity, Nuclear Physics
Dr Saleh Hasan Naqib *MSc(Raj), PhD(Cambridge)*	Superconductivity, Topological Semimetals and Insulators, Computational Condensed Matter Physics
Dr Abul Kalam Fazlul Haque	Atomic and Molecular Physics, Nuclear Physics

MSc(Raj), PhD(Raj)	
Dr Abdullah Shams Bin Tariq *MSc(Raj), PhD(Southampton)*	Particle Physics, Nuclear Physics
Professors(cont.)	
Dr Raihana Shams Islam *M Phil(Cambridge), PhD(Cambridge)*	Superconductivity, Computational Physics
Dr Fahmida Parvin *MSc(Raj), PhD(Raj)*	Superconductivity, Computational Condensed Matter Physics
Dr M A Razzaque Sarker *MSc(Raj),PhD(Yamanashi, Japan)*	Materials Science
Dr M Atiqur Rahman Patoary *MSc(Raj), MSc(Ryukyus, Japan), PhD(Ryukyus, Japan)*	Nuclear Physics, Condensed Matter Physics (Theory)
Dr M Samiul Islam Sarker *MSc(Raj), MSc(Adelaide, Australia), PhD(Tohoku, Japan)*	Nuclear Physics, Fibre-laser, Materials Science
Dr M Monirul Haque *MSc(Raj), PhD (Ritsumeikan, Japan)*	Medical Physics, Radiation and Health Physics
Dr M Saiful Islam *MSc(Raj), PhD(Kyushu, Japan)*	Nanoscience, Computational Condensed Matter Physics, Materials Science
Associate Professors	
Dr Monira Jannatul Kobra *MSc(Raj), PGD(ICTP, Italy), PhD (Kyushu, Japan)*	Nuclear Physics
Dr M Ismail Hossain *MSc(Raj), PhD(Saitama, Japan)*	Theoretical Atomic Physics
Mr M Masum Billah *MSc(Raj)*	Atomic and Molecular Physics, Nuclear Physics
Mr K M Mahmudul Hasan *MSc(Raj)*	Atomic and Molecular Physics, Nuclear Physics
Assistant Professors	
Mr M Leaket Ali* *MSc(Raj)*	Condensed Matter Physics
Dr M Alamgir Hossain *MSc(Raj), PhD(Kyushu, Japan)*	Medical Physics
Mr M Saifur Rahman *MSc(Raj)*	Materials Science
Lecturers	
Dr M Riju Khandaker *MSc(Raj), PhD(Yamanashi, Japan)*	Materials Science

Dr M Abdur Rashid *MSc(Raj), PhD(Hiroshima, Japan)*	Computational Physics, Glass and Glass Ceramics

* *on Study Leave*

Seminar Library

The department may boast to have the biggest seminar library in the university with text and reference books. It also has some international journals, such as Physical Review, Physical Review Letters, Reviews of Modern Physics, which the department had been receiving as a joint contribution from the Abdus Salam International Centre for Theoretical Physics, Italy and American Physical Society. The library is constantly being updated with reference books and other reading materials. There is a rental library for students. Groups of students are able to borrow important textbooks through this service. Besides, a significant number of e-books and a very large number of e-journals are accessible online through the University Central Library.

Computer Facilities

The department has established a computer lab with internet facilities for students and teachers. Recently a Computer Lab based on an N-Computing (thin client) system has been established for students. Research students also have access to computers and internet in their research labs.

Workshop

A mechanical workshop was established in the department from the beginning of the department. The students can get training in the workshop on some instrumentation, as a part of their laboratory experiments. It also serves as a centre for minor repairs of laboratory equipment.

From the inception, the department of physics is known to be one of the most disciplined departments in the university, both in administration and in academic activities. Academic members are very particular in completing their courses, conducting examinations and publishing results according to the calendar published by the department at the beginning of every academic year. It is the tradition of the department to publish the examination results within the quickest possible time and thus it has become possible for the department to avoid the academic backlog in the university. The department constantly reviews its curriculum and takes steps to enhance facilities to match the present day need and thus prepares the students to face the challenges of the future.

Co- and Extra- Curricular Activities

Study tour

The department arranges study tour within Bangladesh (and/or abroad) for the M.Sc. Students each year. The tour is partly financed by the University.

Picnic

Almost every year the Physics Society organizes annual picnic in cooperation with the academic and non-academic staff.

Physics Society

There is a society in the department called Physics Society. All students and teachers of the department are the members of the Society. This society organizes farewell for the outgoing M.Sc. students and welcome reception for the fresher's admitted in the B.Sc. course. Besides, the Society arranges various cultural and sports related activities, e.g. indoor games, management of department sports' teams etc.

Physics Alumni Association

Department of Physics has an active Alumni Association. The objectives of this association are to build active communication network among all the present and ex-students of the Department of Physics through various programs and to contribute in the academic development of the department and the economic development of the country.

Sports and Culture

Students of Department of Physics participate in all inter-department games organized by the RU. The department has achieved notable success in sports by winning matches in cricket, football, badminton, table tennis etc. The students of the department have also participated in various cultural events with distinction.

Physics Club

Physics Club was established in 2011. Since then Physics Club had been providing the students and the faculty members with an open platform to discuss various topics in physics outside the class hour. It had also been organising the Regional Round of the Bangladesh Physics Olympiad for several years. This club is open to all the students of Department of Physics, University of Rajshahi (RU). This club has been inactive in the recent years, but may be revived if students are interested.

English Club

English Club was established in 2010. This club was established with the aim to develop speaking, reading, and writing skills of the students of this department. Only the members of the English Club are permitted to participate in various club activities. This club has been inactive in the recent years, but may be revived if students are interested.

Curriculum for B.Sc. (Hons) in Physics, Session 2024-2028

Title of the Academic Program: Bachelor of Science (Honours) in Physics

Name of the University: University of Rajshahi

Vision of the University
To pursue enlightenment and creativity for producing world-class human resources to cater for the needs of changing time.

Mission of the University
1. To ensure a world-class curriculum with talented academicians and conducive academic and research environment for generation and dissemination of knowledge.
2. To maintain international standards in education with focus on both knowledge and skills, and humanitarian and ethical values to meet the needs of the society and state.
3. To develop strategic partnerships with leading national and international universities, and organizations for academic as well as research collaborations.

Name of the Degree: B.Sc.(Hons) in Physics

Name of the Faculty Offering the Program: Faculty of Science

Name of the Department Offering the Program: Department of Physics

Vision of the Department
To maintain and enhance the reputation of being a disciplined, dedicated and quality institution of physics teaching and research attracting better students, producing graduates with high acceptance amongst employers and serving better input for advanced research.

Mission of the Department
To equip students with the understanding and skills of basic and specialized physics and related courses necessary to proceed for higher studies and research and produce disciplined, diligent, skilled and morally enriched graduates for employment in physics, physics-related and other disciplines.

Objectives of the Department
Since its inception in 1958, the objective of the Department of Physics, University of Rajshahi has been to progress the knowledge in various branches of Physics via teaching-learning and research. The academic program is focused on the creation, translation, and dissemination of knowledge on the subject matter. The strategic goals of the Department are to:

- Support the aims and objectives of the University within the capacity of our Departmental program.

- Advance the academic, research, scholarship and service priorities, consistent with a top tier university, and continue to promote growth and national prominence in these areas.
- Train and produce high-quality graduates to meet up national and international requirements in scientific sectors of the job market.
- Enhance the teaching-learning and research capacities of the Department by retaining and recruiting outstanding faculty and staff.
- Enhance the Department's learning environment by attracting and retaining students of high intellectual ability and aptitude.

B.Sc. (Hons.) Program Learning Outcomes (PLOs)

Knowledge and Understanding

The B.Sc. Degree programs offered by the Department cover the fundamental topics of Physics. It also provides a selection of advanced topics and develops experimental, mathematical, computational, and other transferable skills. On successful completion of these programs a student should have-

PLO1. Knowledge and understanding of most fundamental physical laws and principles and competence in the application of these principles to diverse branches of Physics and closely related disciplines.

PLO2. An ability to solve problems in Physics using appropriate mathematical tools.

PLO3. An ability to execute and analyze the results of an experimental investigation or theoretical modeling and to draw valid conclusions with an estimate of the uncertainty in the result. An ability to compare experimental results with the predictions of relevant theories.

PLO4. A knowledge of the fundamental principles and applications of some of them in advanced areas of Physics.

PLO5. An ability to use IT packages and a competence of the usage of analytical software in problem solving.

PLO6. An ability to communicate scientific information verbally and in the form of clear and accurate scientific reports.

PLO7. An ability to make appropriate use information and communication technologies in regard to problem solving in different sectors of Physics.

Knowledge and understanding of areas 1 – 2, and 4 – 7 are acquired through lectures, tutorials, problem classes and guided independent study. The practically oriented knowledge of area 3 is acquired in practical classes, both experimental and computing, and in thesis work.

A B.Sc. student, after completion of his/her degree from the Department is expected to have the following mental attributes:

PLO8. An understanding and appreciation of current issues and debates in various branches of Physics.

PLO9. An understanding and appreciation of the philosophical bases, mathematical structure, methodologies, characteristics of scientific scholarship, research, and creative work.

PLO10. An ability to work independently and in collaboration with others.

PLO11. Personal and professional integrity and an awareness of the requirements of ethical behavior.

At personal level, the graduates are expected to have the following skills:

PLO12. Competence in using computer software and programming languages.

PLO13. Competence in troubleshooting and solving basic problems in electronic equipments and circuits.

PLO14. An ability to prepare multimedia presentations for conveying scientific facts and findings to audience with diverse backgrounds.

Mapping of Programme Learning Outcomes (PLOs) with Course Learning Outcomes (CLOs) of the B.Sc. (Hons) programme in Physics at the University of Rajshahi

	Domain	Cognitive								Affective					Psychomotor		
	PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7		PLO8	PLO9	PLO10	PLO11		PLO12	PLO13	PLO14
1st Year 1st Semester	PH1101	X															
	PH1102	X															
	PH1103	X															
	PH1111		X														
	PH1112		X														
	PH1113	X															
	PH1114		X														
	PH1121	X		X								X	X				
	PH1122	X		X								X	X			X	
1st Year 2nd Semester	PH1201	X															
	PH1202	X															
	PH1211		X														
	PH1212	X															
	PH1213		X														
	PH1214		X														
	PH1215		X														
	PH1221	X		X								X	X				
	PH1222	X		X								X	X				
	PH1231						X										
2nd Year 1st Semester	PH2101	X															
	PH2102	X															
	PH2103	X															
	PH2111	X															
	PH2112		X														
	PH2113					X		X							X		X
	PH2121	X		X								X	X				
	PH2122	X		X								X	X			X	

	Domain	Cognitive							Affective				Psychomotor		
	PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	PLO13	PLO14
2nd Year 1st Semester	PH2201	X													
	PH2202	X								X					
	PH2203	X													
	PH2211		X												
	PH2212		X												
	PH2213					X		X					X		
	PH2221			X		X		X					X		X
	PH2222	X		X											
	PH2231						X								
3rd Year 1st Semester	PH3101	X													
	PH3102	X								X					
	PH3103	X								X					
	PH3104	X													
	PH3105	X												X	
	PH3106	X												X	
	PH3121	X		X							X	X			
	PH3122	X		X							X	X		X	
3rd Year 2nd Semester	PH3201	X													
	PH3202	X								X					
	PH3203	X								X					
	PH3204	X													
	PH3205	X													
	PH3211	X							X						
	PH3221	X		X							X	X			
	PH3222	X		X							X	X		X	
	PH3231						X								
4th Year 1st Semester	PH4101	X								X					
	PH4102	X								X					
	PH4103	X													
	PH4104	X													
	PH4105	X												X	
	PH4106	X							X						
	PH4107	X													
	PH4121	X		X							X	X			
	PH4122	X		X							X	X		X	
4th Year 2nd Semester	PH4201	X								X					
	PH4202	X													
	PH4203	X													
	PH4204	X							X						
	PH4205	X							X	X					
	PH4221	X		X							X	X			
	PH4222	X		X							X	X		X	
	PH4231						X								
	PH4241	X	X	X	X	X	X	X			X	X	X		X

UNIVERSITY OF RAJSHAHI
FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

B.Sc. (Honours) Curriculum
Session: **2024-2028**

Examinations: **2025** (1/1 and 1/2); **2026** (2/1 and 2/2); **2027** (3/1 and 3/2) and **2028** (4/1 and 4/2).

The B.Sc. (Honours) in Physics programme is spread over **four years** and each academic year shall be divided into **two semesters.** Over the four years, there is a total of **4000 marks**, **160 Credits.** The marks distribution shall be of 1000 marks in each of the years, with 475 marks in the 1st (odd) semesters of each year and 525 marks in the 2nd (even) semesters, including a 50-mark viva-voce.

A 3-credit course shall carry 75 marks and a 2-credit course 50 marks out of which 70% is for the final written exam, 20% for in-course evaluation and 10% for class attendance. Total number of contact hours in a 3-credit course should be approximately 42 and that for a 2-credit course 28. The duration of examination for the theoretical papers shall be 3 hours for a 3-credit and 2 hours for a 2-credit course.

For laboratory / practical courses 60% is for the final exam, 30% for in-course evaluation and 10% for class attendance. Total number of contact hours for a 2-credit lab course should be approximately 56. The duration of examination for the practical courses shall be 6 hours for a 2-credit course.

The minimum marks/grade points required for the promotions and for obtaining the B.Sc. (Honours) degree will be according to the ordinance.

Important points of the Ordinance for the Degree of Bachelor of Science with Honours in Physics

Grading System

Numerical Grade (NG)	Letter Grade (LG)	Grade Point (GP)
80% and above	**A$^+$** (A Plus)	**4.00**
75% to less than 80%	**A** (A regular)	**3.75**
70% to less than 75%	**A$^-$** (A minus)	**3.50**
65% to less than 70%	**B$^+$** (B Plus)	**3.25**
60% to less than 65%	**B** (B regular)	**3.00**
55% to less than 60%	**B$^-$** (B minus)	**2.75**
50% to less than 55%	**C$^+$** (C Plus)	**2.50**
45% to less than 50%	**C** (C regular)	**2.25**
40% to less than 45%	**D**	**2.00**
Less to than 40%	**F**	**0.00**

An illustration of calculating Semester GPA – SGPA, Yearly GPA – YGPA and Cumulative GPA – CGPA: Suppose a student has completed five courses in First and Second Semester of First Year and four courses in First and Second Semester of Second Year examinations and obtained the following grades:

First Year First Semester	Credits	Grade	GP
Chem-101	2	A	3.75
Chem-111	4	A+	4.00
Chem-112	4	B+	3.25
Chem-131	4	B–	2.75
Math-142	4	C	2.25

$$(\text{SGPA})_1 = \frac{2(3.75) + 4(4.00) + 4(3.25) + 4(2.75) + 4(2.25)}{2 + 4 + 4 + 4 + 4} = \frac{56.50}{18} = 3.13888 = 3.138$$

First Year Second Semester	Credits	Grade	GP
Chem-103	4	A+	4.00
Chem-115	4	B	3.00
Chem-127	4	A	3.75
Math-145	2	B+	3.25
PH-151	2	A–	3.50

$$(\text{SGPA})_2 = \frac{4(4.00) + 4(3.00) + 4(3.75) + 2(3.25) + 2(3.50)}{4 + 4 + 4 + 2 + 2} = \frac{56.50}{16} = 3.53125 = 3.531$$

$$(\text{YGPA})_1 = \frac{3.138 \times 18 + 3.531 \times 16}{18 + 16} = \frac{112.980}{34} = 3.32294 = 3.322$$

Second Year First Semester	Credits	Grade	GP
Chem-211	4	B	3.00
Chem-212	3	B	3.00
Chem-221	4	C	2.50
Chem-231	2	A	3.75

$$(\text{SGPA})_3 = \frac{4(3.00) + 3(3.00) + 4(2.50) + 2(3.75)}{4 + 3 + 4 + 2} = \frac{38.50}{13} = 2.96153 = 2.961$$

Second Year Second Semester	Credits	Grade	GP
Chem-201	2	A–	3.50
Chem-212	2	B	3.00
Chem-222	2	C	2.25
Chem-232	4	D	2.00

$$(\mathrm{SGPA})_4 = \frac{2(3.50) + 2(3.00) + 2(2.25) + 4(2.00)}{2 + 2 + 2 + 4} = \frac{25.50}{10} = 2.55000 = 2.550$$

$$(\mathrm{YGPA})_2 = \frac{2.961 \times 13 + 2.550 \times 10}{13 + 10} = \frac{63.993}{23} = 2.78230 = 2.782$$

Similarly, if his/her $(\mathrm{YGPA})_3$ and $(\mathrm{YGPA})_4$ are 3.127 and 3.053 respectively and corresponding YTCP are 30 and 33, then CGPA is:

$$\mathrm{CGPA} = \frac{3.322 \times 34 + 2.782 \times 23 + 3.127 \times 30 + 3.053 \times 33}{34 + 23 + 30 + 33} = \frac{371.493}{120} = 3.09577 = 3.10$$

LG corresponding to CGPA = 3.10 is “B”.

SGPA, YGPA Truncation and CGPA Round off

SGPA and YGPA shall be rounded down to 3 (three) places after decimal. For instance, SGPA = 2.1126 shall be rounded down as SGPA = 2.112.

In case of CGPA, it shall be rounded to 2 (two) places after decimal. If third digit after decimal is 5 (five) and above, 1 (one) should be added with second digit after decimal. For instance, CGPA = 2.112 shall be rounded as CGPA = 2.11 and CGPA = 2.115 rounded as CGPA = 2.12.

Marks Distribution for Theoretical Courses

- Class Attendance/Participation: 10%
- Class Test/Assignment/Mid-Terms/Quizzes etc.: 20%
- Final Examination: 70%

Marks Distribution for Practical Courses

- Class Attendance/Participation: 10%
- Continuous Assessment and/or Report: 30%
- Practical Examination: 60%

Class Attendance

Table for awarding marks for attendance

Attendance	Marks	**Attendance**	Marks	**Attendance**	Marks
≥ 90%	*100%*	75 - <80%	*70%*	60 - <65%	*40%*
85 - <90%	*90%*	70 - <75%	*60%*	<60%	*00%*
80 - <85%	*80%*	65 - <70%	*50%*		

A student attending a minimum of 75% class (regular) shall be allowed to sit for the final examination. A student attending to 60% **to** <75% of classes (non-collegiate) shall be allowed to sit for the final examination with a fine of Tk. 1000/-. A student with less than 60% class attendance shall be considered as dis-collegiate and shall not be allowed to sit for the final examination. **Award of Degrees, Promotions and Improvement of Results**

A) Award of Degree

In order to obtain the B.Sc. (Honors)/B.Pharm. (Honors) Degree, a student must fulfil the following conditions:

i) The Degree program must be completed within a minimum of 4 and a maximum of 6 academic years from the date of admission. No student shall be allowed to stay for more than 2 consecutive terms in the same semester/year.

ii) The minimum CGPA for awarding B.Sc. (Honors)/ B.Pharm. (Honors) Degree is 2.50 out of 4.0.

iii) Total Credit Point (TCP) required for awarding the Degree is 152.

B) Promotions

In order to be promoted to the next academic year a student shall fulfil the following requirements:

a) The minimum Year Grade Point Average (YGPA) for the promotion from each academic year to the next is as follows:

Academic Year	Minimum YGPA
First Year	2.00
Second Year	2.25
Third Year	2.50
Fourth Year	2.50

b) A maximum of 8 credits can be relaxed in theoretical courses to be promoted to the next academic year. If a student fails to be promoted to next year (s)he will be readmitted in the same year in the next academic year.

C) Course Improvement

i) A promoted student shall only be allowed to appear in the theoretical course improvement examination in the immediate next academic year for one time in order to improve a maximum of two theory courses including F-grade course. To clear F-grade the candidate shall be allowed to appear in the examination for maximum two times in immediate consecutive similar semesters. This shall be applicable up to Fourth Year First Semester.

ii) Theoretical course improvement shall only be allowed if the earned grade is less than letter grade B minus (< 2.75 GP).

iii) In practical course a student shall not be allowed to appear in clearing F grade or improvement examination.

iv) A student shall carry his/her previous marks on continuous assessment (CA).

v) In the case of student`s failure to improve course grade at the course improvement examination, the previous grade shall remain valid.

D) Final Result (CGPA) Improvement

A student obtaining the Bachelor (Honors) Degree within 4 or 5 academic years shall only be allowed to improve his/her result in the immediate next regular examination after publication of result. A student shall only be allowed to take part in result improvement examination for a maximum of two theoretical courses (maximum 6 credits) of the last semester (Fourth Year Second Semester). Result improvement in theoretical courses shall only be allowed if the earned grade is less than letter grade B (CGPA < 3.00).

E) Readmission

If a student fails to be promoted to next year (s)he will be readmitted in the same year in the next academic year.

Subject-wise distribution of Credits

Type	**Core**				**GEd**						**Total**
Sub-ject	**Physics**				**Maths**	**Che-mistry**	**Statis-tics**	**Compu-tation**	**Environ-ment**	**GEd Total**	
Semes-ter	Theo-retical	Prac-tical	Oral	**Total**	Theo-retical	Theo-retical	Theo-retical	Theo-retical	Theo-retical		
1/1	*7*	*4*		**11**	*4*	*2*	*2*			**8**	**19**
1/2	*4*	*4*	*2*	**10**	*7*	*2*	*2*			**11**	**21**
2/1	*6*	*4*		**10**	*3*	*3*		*3*		**9**	**19**
2/2	*6*	*4*	*2*	**12**	*6*			*3*		**9**	**21**
3/1	*12*	*4*		**16**					*3*	**3**	**19**
3/2	*15*	*4*	*2*	**21**							**21**
4/1	*15*	*4*		**19**							**19**
4/2	*15*	*4*	*2*	**21**							**21**
Total	**80**	**32**	**8**	**120**	**20**	**7**	**4**	**6**	**3**	**40**	
Subject	Physics				Maths	Che-mistry	Statis-tics	Compu-tation	Environ-ment	GEd Total	

Detailed Distribution of Courses

Courses in 1st Year 1st Semester B.Sc. (Honours) Curriculum: Examination 2025

Course no.	Title	Marks	Status	Exam. duration	CP
PH1101	Mechanics	50	Core	2 hours	02
PH1102	Electromagnetism-I	50	Core	2 hours	02
PH1103	Vibrations and Waves	75	Core	3 hours	03
PH1111	Vector Analysis	50	GEd	2 hours	02
PH1112	Differential Calculus	50	GEd	2 hours	02
PH1113	Inorganic Chemistry	50	GEd	2 hours	02
PH1114	Principles of Statistics-I	50	GEd	2 hours	02
PH1121	Physical Measurements Practical	50	Core	6 hours	02
PH1122	Mechanics Practical	50	Core	6 hours	02

Total marks: 475 **TCP: 19**

Courses in 1st Year 2nd Semester B.Sc. (Honours) Curriculum: Examination 2025

Course no.	Title	Marks	Status	Exam. duration	CP
PH1201	Properties of Matter	50	Core	2 hours	02
PH1202	Electromagnetism-II	50	Core	2 hours	02
PH1211	Differential Equations	50	GEd	2 hours	02
PH1212	Integral Calculus	50	GEd	2 hours	02
PH1213	Organic Chemistry	50	GEd	2 hours	02
PH1214	Principles of Statistics-II	50	GEd	2 hours	02
PH1215	Solid Geometry and Algebra	75	GEd	3 hours	03
PH1221	Properties of Matter Practical	50	Core	6 hours	02
PH1222	Electromagnetism Practical	50	Core	6 hours	02
PH1231	Viva-Voce	50	Core	--	02

Total marks: 525 **TCP: 21**

Courses in 2nd Year 1st Semester B.Sc. (Honours) Curriculum: Examination 2026

Course no.	Title	Marks	Status	Exam. duration	CP
PH2101	Optics	50	Core	2 hours	02
PH2102	Heat and Radiation	50	Core	2 hours	02
PH2103	Classical Mechanics-I	50	Core	2 hours	02
PH2111	Physical Chemistry	75	GEd	3 hours	03
PH2112	Numerical Methods	75	GEd	3 hours	03
PH2113	Computer Programming	75	GEd	3 hours	03
PH2121	Heat and Radiation Practical	50	Core	6 hours	02
PH2122	Electronics and Electricity Practical	50	Core	6 hours	02
		Total marks: 475			**TCP: 19**

Courses in 2nd Year 2nd Semester B.Sc. (Honours) Curriculum: Examination 2026

Course no.	Title	Marks	Status	Exam. duration	CP
PH2201	Nonlinear and Fibre Optics	50	Core	2 hours	02
PH2202	Thermodynamics	50	Core	2 hours	02
PH2203	Classical Mechanics-II	50	Core	2 hours	02
PH2211	Matrices and Tensors	75	GEd	3 hours	03
PH2212	Special Functions and Complex Variables	75	GEd	3 hours	03
PH2213	Computational Physics	75	GEd	3 hours	03
PH2221	Computer Programming Practical	50	Core	6 hours	02
PH2222	Optics Practical	50	Core	6 hours	02
PH2231	Viva-Voce	50	Core	--	02
		Total marks: 525			**TCP: 21**

Courses in 3rd Year 1st Semester B.Sc. (Honours) Curriculum: Examination 2027

Course no.	Title	Marks	Status	Exam. duration	CP
PH3101	Electrodynamics-I	50	Core	2 hours	02
PH3102	Quantum Mechanics-I	50	Core	2 hours	02
PH3103	Relativity	75	Core	3 hours	03
PH3104	Solid State Physics-I	75	Core	3 hours	03
PH3105	Circuit Analysis and Electronics Fundamentals	75	Core	3 hours	03
PH3106	Electronics	50	Core	2 hours	02
PH3121	Modern Physics Practical-I	50	Core	6 hours	02
PH3122	Electronics Practical-I	50	Core	6 hours	02
	Total marks: 475				**TCP: 19**

Courses in 3rd Year 2nd Semester B.Sc. (Honours) Curriculum: Examination 2027

Course no.	Title	Marks	Status	Exam. duration	CP
PH3201	Electrodynamics-II	50	Core	2 hours	02
PH3202	Quantum Mechanics-II	50	Core	2 hours	02
PH3203	Statistical Mechanics-I	50	Core	2 hours	02
PH3204	Atomic and Molecular Physics	75	Core	3 hours	03
PH3205	Nuclear Physics-I	75	Core	3 hours	03
PH3211	Renewable Energy and Meteorology	75	GEd	3 hours	03
PH3221	Modern Physics Practical-II	50	Core	6 hours	02
PH3222	Electronics Practical-II	50	Core	6 hours	02
PH3231	Viva-Voce	50	Core	--	02
	Total marks: 525				**TCP: 21**

Courses in 4th Year 1st Semester B.Sc. (Honours) Curriculum: Examination 2028

Course no.	Title	Marks	Status	Exam. duration	CP
PH4101	Quantum Mechanics-III	50	Core	2 hours	02
PH4102	Statistical Mechanics-II	50	Core	2 hours	02
PH4103	Nuclear Physics-II	50	Core	2 hours	02
PH4104	Solid State Physics-II	50	Core	2 hours	02
PH4105	Pulse and Digital Electronics	75	Core	3 hours	03
PH4106	Reactor Physics	50	Core	2 hours	02
PH4107	Particle Physics	50	Core	2 hours	02
PH4121	Nuclear Physics Practical	50	Core	6 hours	02
PH4122	Electronics Practical-III	50	Core	6 hours	02
	Total marks: 475				**TCP: 19**

Courses in 4th Year 2nd Semester B.Sc. (Honours) Curriculum: Examination 2028

Course no.	Title	Marks	Status	Exam. duration	CP
PH4201	Quantum Mechanics-IV	50	Core	2 hours	02
PH4202	Materials Science and Nanophysics	50	Core	2 hours	02
PH4203	Crystallography	75	Core	3 hours	03
PH4204	Medical and Radiation Physics	75	Core	3 hours	03
PH4205	Astronomy and Cosmology	75	Core	3 hours	03
PH4221	Solid State Physics Practical	50	Core	6 hours	02
PH4222	Electronics Practical-IV	50	Core	6 hours	02
PH4231	Viva-Voce	50	Core	--	02
PH4241	Project/Fieldwork/ Academic Excursion	50	Core	--	02
	Total marks: 525				**TCP: 21**

Notes

Course Numbering

First digit: Year
Second digit: Semester within year
Third digit: Course type: 0-core, 1-G.Ed./minor, 2-Lab, 3-Viva, 4-Project

1st Year 1st Semester

PH1101 MECHANICS	(~28 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: **50** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* **2** *hours*

Prerequisites: Intermediate level vector algebra, mechanics and general physics

Course Objectives and Summary: This is a basic course in physics to describe translational and rotational motion and motion in a gravitational field

1. **Motion:** Implications of Newton's Laws of Motion; Kinematics in two and three Dimensions; Projectile Motion; Uniform Circular Motion; Conservative and Non-Conservative Forces; Friction in Dynamical Problems; Potential Energy Function; Conservation of Energy and Momentum; Collision Problems; Center of Gravity and Mass.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Calculate the angle at which an object can be thrown to a maximum distance.
   - **(ii)** Explain the performances of athletes, cannon firing, bombing from airplane.
   - **(iii)** Analyze the use of potential energy and kinetic energy in different mechanical systems.
   - **(iv)** Apply the conservation principles to different dynamical phenomena.
   - **(v)** Separate the conservative and non-conservative forces.
   - **(vi)** Find out the mechanism of calculating the center of mass and center of gravity of a system.

2. **Rotational Dynamics:** Torque and Angular Momentum; Conservation of Angular Momentum; Kinetic Energy of Rotation and Rotational Inertia; Theorems of Parallel and Perpendicular Axes for Calculations of Moment of Inertia; Calculations of Moment of Inertia of Solids of Different Shapes; Combined Translational and Rotational Motion of a Rigid Body.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Apply the conservation of angular momentum to different dynamical problems.
   - **(ii)** Calculate moment of inertia for different geometrical shapes for various axes of rotation.
   - **(iii)** Solve problems involving complex (translational plus rotational) motion.
   - **(iv)** Explain the mechanism of storing energy and its uses in industry using devices like flywheels.

3. **Gravitation:** Law of Universal Gravitation; Determination of Universal Gravitation Constant G; Inertial and Gravitational Mass; Variation in Acceleration due to Gravity; Gravitational Field and Potential; Gravitational Field Equations; Motion of Planets and Satellites, Kepler's Laws; Gravitational Potential Energy and Escape Velocity.

Intended learning outcomes: Enable the successful students to:

- **(i)** Relate the concepts of gravitational field intensity to gravitational potential at a point.
- **(ii)** Calculate gravitational potentials and gravitational fields for different mass distributions.
- **(iii)** Derive the equation for the orbit of a mass under central force.
- **(iv)** Explain and derive Kepler's law of planetary motion.
- **(v)** Calculate the escape velocity.
- **(vi)** Explain the basics of satellite motion.
- **(vii)** Describe the use of gravitational force in our daily life events.

Books Recommended

Text Books

Halliday, D, Resnick, R & Walker, J	Fundamentals of Physics (10th edition)
Resnick, R, Halliday, D & Krane, K	Physics Part I (5th edition)

Reference Books

Kleppner, D and Kolenkow, R	Introduction to Mechanics
Symon, KR	Mechanics
Spiegel, MR	Vector Analysis
Young, H and Freedman, R	University Physics
Heuvelen, AV	Physics
Constant, FW	Theoretical Physics (Part I)
Spiegel, MR	Theoretical Mechanics
Randall D. Knight	Physics for Scientists & Engineers (2nd ed.)
Douglas C. Giancoli	Physics for Scientists & Engineers (4th ed.)

PH1102 ELECTROMAGNETISM-I (~28 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: **50** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* **2** *hours*

Prerequisites: Concepts of electric charge, flow of charge through a medium, electric potential, electric field, and production of e.m.f.

Course Objectives and Summary: This course integrates key concepts in Electrostatics, Electric Current, and Alternating Current. Students will learn principles such as Coulomb's Law, Ohm's Law, and AC Fundamentals. Emphasis is placed on understanding Electric Fields, Kirchhoff's Laws, and Phasor Diagrams. The course equips students with essential skills for analyzing and designing electrical systems, emphasizing theoretical comprehension and practical applications.

1. **Electrostatics:** Coulomb's Law; Electric Field; Electric Potential and Potential Function; Gauss' Law and its Applications; Electric Dipole and Quadrupole; Electric Field in Dielectric Media; Polarization; Gauss' Law for Dielectrics; Permittivity; Condensers; Boundary Value Problems- Poisson's and Laplace's Equations.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Calculate force acting between two charges.
   - **(ii)** Calculate electric field for different kinds of charge distribution.
   - **(iii)** Visualize electric field using field strength, field lines and potential.
   - **(iv)** Explain the effect of dielectric materials on electric field.
   - **(v)** Calculate electric field for symmetric charge distribution using Gauss's law.
   - **(vi)** Explain the mechanism of storing energy in a capacitor.

2. **Electric Current:** Ohm's Law; Current Density; Conductivity; Resistivity; Kirchhoff's Laws and their Applications.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Characterise ohmic materials using current-voltage plot.
   - **(ii)** Explain why the resistivity is constant but resistance is not for a material.
   - **(iii)** Analyze both single and multi loop circuits.

3. **Alternating Current:** AC Fundamentals; Power and Power Equations; AC Circuits with L, C and R only and their Combinations; Use of Complex Quantities and Phasor Diagrams of Reactance and Voltage in AC Circuits; LC Oscillations; Resonant and Anti-Resonant Circuits; Q Factors; Transformers; AC Measuring Instruments, AC Bridge; Oscilloscope.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Distinguish between ac and dc circuits using graphical representations.
   - **(ii)** Explain the mechanism of LC oscillations, generation of ac voltage and current.
   - **(iii)** Analyze pure resistive, capacitive and inductive circuits.
   - **(iv)** Analyze RC, LC, series LCR and parallel LCR circuits using conventional method as well as phasor diagram.
   - **(v)** Calculate and visualize graphically the growth and decay of currents in the above circuits.
   - **(vi)** Calculate the half power point, band width and Q value of LCR series and parallel circuits.

Books Recommended

Text Books

Halliday, D, Resnick, R & Walker, J	Fundamentals of Physics
Rafiqullah, AK et al.	Concepts of Electricity and Magnetism
Tewari, KK	Electricity and Magnetism
Islam, AKMA et al.	Tarit Chumbak Tatwa O Adhunik Padarthavijnan *(in Bangla)*
Theraja, BL	Text Book of Electrical Technology

Reference Books

Kip, A	Fundamentals of Electricity and Magnetism

Young, H and Freedman, R	University Physics
Duffin, WJ	Electricity and Magnetism
Page, L and Adams, NI	Principles of Electrical Technology
Purcell, EM	Electricity and Magnetism
Agarwal, JP	Circuit Fundamentals and Basic Electronics
Griffiths, D	Introduction to Electrodynamics
Resnick, R, Halliday, D & Krane, K	Physics Part II (5th edition)

PH1103 VIBRATIONS AND WAVES (~42 contact hours)

Course Type: Core *Credit Point: 3*

Full Marks: **75** (*Written Examination 52.5, In-course Evaluation 15 and Attendance 7.5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***3*** *hours*

Prerequisites: HSC level waves and sound

Course Objectives and Summary: This course aims to provide students with an overview of the simple harmonic motion in various circumstances as well as waves in various forms. The course addresses free, damped and forced oscillators, and resonance. Students will gain useful concepts and mathematical tools to explain broad range of problems related to vibrations and waves from this course.

1. **Free Vibration:** Harmonic Motion; Mathematical Representation; Boundary Conditions; Vector Representation: Velocity; Acceleration and their Phase Relationship; Energy of a Harmonic Oscillator; Physical and Torsional Pendulums; Plasma Vibration.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Explain harmonic motion.
   - **(ii)** Explain the origin of restoring force from potential gradient and the mechanism of simple harmonic motion.
   - **(iii)** Demonstrate the variation of kinetic and potential energies of a harmonic oscillator.
   - **(iv)** Explain the vibrations in outer space plasma.

2. **Damped and Forced Vibrations:** Damping Forces; Types of Damping; Logarithmic Decrement; Relaxation Time and Quality (Q) Factor; Electromagnetic Damping; Forced Oscillation; Steady State and Transient Solutions; Variation of Driving Frequency; Examples of Resonance.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Explain the effect of damping force on free vibrations.
   - **(ii)** Explain different types of damping and use it in engineering purposes such as circuits, construction of dead beat and ballistic galvanometer etc.
   - **(iii)** Explain forced oscillations and the resonance phenomenon.

3. **Fundamentals of Waves**: Wave Motion, Types of Waves; Wave Generation; Wave Equation and Solution; Energy Power and Speed of Traveling Waves.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Visualize wave motion and develop intuition about waves. Understand how waves travel through a medium.
   - **(ii)** Understand the difference between transverse and longitudinal waves.
   - **(iii)** Become familiar with the properties of sinusoidal waves, such as wavelength, wave speed, amplitude, and frequency.
   - **(iv)** Study the properties of common waves - waves on strings, sound waves, and light waves.
   - **(v)** Apply energy and power concepts to waves.

4. **Superposition of Periodic Motions:** Principle of Superposition; Superimposed Vibration of Equal and Different Frequencies; Stationary Waves; Beats; Combination of two Vibrations at Right Angles; Lissajous Figures.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Explain the principle of superposition.
   - **(ii)** Explain the production of standing wave and the basics of harmonics.
   - **(iii)** Describe the production of beats and the details of tuning a musical instrument.
   - **(iv)** Describe the production of Lissajous figure for different combinations.

5. **Sound Waves and Acoustics:** Sources; Propagation and Speed of Sound in Fluid and Solid Media; Musical Sound; Doppler's Effect; Infrasonics and Ultrasonics.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Explain the properties of musical sound.
   - **(ii)** Explain Doppler's effect and its basic uses in astronomy, medical imaging, flow measurement, radar etc.

Books Recommended

Text Books

Main, IG	Vibrations and Waves in Physics
King, GC	Vibrations and Waves
Puri, SP	Vibrations and Waves
Pain, HJ	Physics of Vibrations and Waves
French, AP	Vibrations and Waves

Reference Books

Halliday, D and Resnick, R	Fundamentals of Physics
Morse, PM	Vibration and Sound
Smith, WF	Waves and Oscillations: A Prelude to Quantum Mechanics
Georgi, H	Physics of Waves

PH1111 VECTOR ANALYSIS (~28 contact hours)

Course Type: GEd *Credit Point: 2*

Full Marks: **50** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* **2** *hours*

Prerequisites: HSC level vector algebra and calculus

Course Objective and Summary: This course includes vector algebra, vector differentiation, integration and different integral theorems. Curvilinear coordinates are described in this course. The differential equations of various types and their solution methods are also discussed in this course.

1. **Vector Sum and Products:** Applications of Dot and Cross Products of Vectors; Scalar Triple Product; Vector Triple Product.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Represent one-, two- and three-dimensional vectors graphically.
   - **(ii)** Understand the physical meanings of scalar and vector products.
   - **(iii)** Use these products in different physical problems such as to calculate work, torque, angular momentum, magnetic force etc.
   - **(iv)** Evaluate triple product and use it in physical problems like lattice vector calculations.

2. **Gradient, Divergence and Curl:** Vector Differentiation; Vector Differential Operator Del; Gradient; Divergence; Curl and their Physical Significance; Formulae Involving Del.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Evaluate gradient, divergence and curl and explain their physical significance.
   - **(ii)** Use these in the physical problems of electrodynamics, thermodynamics etc.
   - **(iii)** Solve problems using the formulae involving the operator Del.

3. **Vector Integration:** Ordinary Integrals of Vectors; Line Integrals; Surface Integrals; Volume Integrals.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Evaluate vector line integrals, surface integrals and volume integrals.
   - **(ii)** Use this integrals in solving physical problems.

4. **Theorems Relating Different Integrals:** Divergence Theorem of Gauss; Green's Theorem in the Plane; Stokes' Theorem.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Prove divergence theorem, Green's theorem and Stoke's theorem.
   - **(ii)** Visualize these theorem using real life events and use these in the problems where dimension(s) of integration are needed to be altered.
   - **(iii)** Use these theorems in deriving equations and to solve problems.

5. **Curvilinear Coordinates:** Frames of Reference – Rectangular; Spherical Polar and Cylindrical Coordinates; Concept of Curvilinear Coordinates; Unit Vectors

in Curvilinear Systems; Line arc Length, Surface and Volume Elements in Different Coordinates.

Intended learning outcomes: Enable the successful students to:

- **(i)** Demonstrate the concept of curvilinear coordinates.
- **(ii)** Visualize rectangular, spherical and cylindrical coordinate systems and use these for suitable symmetry.
- **(iii)** Calculate length, surface and volume element in different coordinate systems.

Books Recommended

Text Books

Spiegel, MR	Vector Analysis and an Introduction to Tensor Analysis
Lass, H	Vector and Tensor Calculus

Reference Books

Simmons, GF and Robertson, JS	Diff. Eqs. With Applications and Historical Notes
Arfken, GB	Mathematical Methods in Physics
Wong, CW	Introduction to Mathematical Physics
Davis, HF and Snider, AD	Introduction to Vector Analysis
Griffths, DJ	Introduction to Electrodynamics

PH1112 DIFFERENTIAL CALCULUS (~28 contact hours)

Course Type: GEd *Credit Point: 2*

Full Marks: ***50*** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***2*** *hours*

Prerequisite: HSC level calculus

Course Objective and Summary: Calculus is an important tool for a physicist. This is a generalized basic undergraduate mathematics course taught by teacher from the Mathematics department. It covers differential calculus and provides students with skills and tools required in physics problems.

1. **Functions:** Domain; Range; Inverse Function and Graphs of Functions; Limits; Continuity and Indeterminate Form.

Intended learning outcomes: Enable the successful students to:

- **(i)** Recognize the properties of functions and their inverses.
- **(ii)** Learn meaning of domain and range of a function, dependent and independent variables and plot the functions accordingly.
- **(iii)** Evaluate limits involving indeterminate forms using L-hospitals rule.
- **(iv)** Evaluate the discontinuities of a function.

2. **Ordinary Differentiation:** Differentiability; Differentiation; Successive Differentiation and Leibniz Theorem.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Learn how a variable changes with respect to another variable.
   - **(ii)** Perform different forms of differentiation.
   - **(iii)** Learn how to differentiate the integral transforms.

3. **Expansions of Functions:** Rolle's Theorem; Mean Value; Taylor's and Maclaurin's Formulae.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Find out the stationary point of a function which has the same two values at particular intervals.
   - **(ii)** Find out the point(s) between two end points of a function, at which the tangent to the arc is parallel to the secant through its endpoints.
   - **(iii)** Evaluate the decreasing or increasing behavior of a function.
   - **(iv)** Explain Taylor's and Maclaurin's Formulae and use these theorems in mathematical and physical problems.

4. **Maxima and Minima of Functions of One Variable.**

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Find out the extrema of physical system (function) by equating the first derivative to zero and maxima and minima from the second derivatives test.
   - **(ii)** Find out the intervals on which a function is increasing/decreasing.

5. **Partial Differentiation:** Euler's Theorem; Tangents and Normals.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Explain the behavior of a function that changes with more than one variable.
   - **(ii)** Implement the use of partial differentiation in demonstrating physical situation, e.g., temperature gradients along three directions, horizontal and vertical damages caused by pollutants, velocity field of a moving fluid, magnetic field etc.

6. **Asymptotes.**

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Demonstrate the asymptotic behavior of a function.
   - **(ii)** Evaluate asymptotes of curves of different patterns.

Books Recommended

Text Books

Das, BC and Mukherjee, BN	Differential Calculus
Muhammad, K and Bhattacherjee, PK	Differential Calculus

Reference Books

Edwards, J	Differential Calculus
Thomas and Finny	Calculus and Analytical Geometry
Swokowsky, E	Calculus and Analytical Geometry
Ayres, F	Calculus

Spiegel, MR Schaum's Outline of Advanced Calculus

PH1113 INORGANIC CHEMISTRY (~28 contact hours)

Course Type: GEd *Credit Point: 2*

Full Marks: ***50*** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***2*** *hours*

Prerequisite: HSC level chemistry

Course Objective and Summary: Chemistry is a closely connected discipline to physics. There are significant areas of overlap and useful applications of chemistry concepts in the study of synthesis and properties of materials. This is a basic undergraduate course covering key concepts in inorganic chemistry.

1. **Atomic Structure:** Elementary Ideas on Atomic Structure; Electronic Configuration of Elements.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Describe atomic structure.
   - **(ii)** Demonstrate the electronic arrangement in different s, p, d, f etc. orbitals of various elements.

2. **Periodic Classification of Elements:** Modern Periodic Table; Periodic Classification of Elements; Correlation of Periodic Classification with Electronic Configuration; Investigation on some Periodic Properties; Atomic Radius; Ionic Radius; Covalent Radius; Ionization Potential; Electron Affinity; Electronegativity.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Have knowledge of periodic table.
   - **(ii)** Organize a set of element or monoatomic ions in order of increasing atomic radius, ionic radius, first ionization energy and electronegativity
   - **(iii)** Explain electronegativity, electron affinity and ionization potential

3. **Group Study of Elements:** Alkali Metals; Alkaline Earth Metals; Halogens; Inert Gases; Transition and Rare Earth Elements.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Explain the properties of alkali metals, alkaline earth metals, halogens, Inert Gases and Transition Elements.
   - **(ii)** Demonstrate the use of inert gases in refrigerator, superconducting magnets, MRI, radiotherapy, laser surgery etc.
   - **(iii)** Demonstrate the use of halogens as disinfectants for drinking water.

4. **Chemical Bond:** Different Types of Chemical Bonding; Hybridization of Atomic Orbitals and Shapes of Molecules; Molecular Orbitals; Bond Length and Bond Strength.

   Intended learning outcomes: Enable the successful students to:

- **(i)** Understand the hybridization and geometry of atoms and the three-dimensional structure of organic molecules
- **(ii)** Determine whether a bond is metallic, ionic, covalent or polar covalent
- **(iii)** Explain the interaction of molecular orbitals and hence demonstrate different types bonding and symmetry.

Books Recommended

Text Books

Haider, SZ	Modern Inorganic Chemistry

Reference Books

Moeller, T	Modern Inorganic Chemistry
Gilreath, E	Fundamental Concepts of InorganicChemistry
Seberra, DK	Electronic Structure and Chemical Bonding
Ahmed, S and Hossain, ML	Snatak Ajaiba Rasayan (*in Bangla*)
Ahmed, AKS	Ajaiba Rasayan (*in Bangla*)

PH1114 PRINCIPLES OF STATISTICS-I (~28 contact hours)

Course Type: GEd *Credit Point: 2*

Full Marks: ***50*** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***2*** *hours*

Prerequisite: HSC level mathematics

Course Objective and Summary: In the analysis of any type of data, statistical tools and concepts are essential. This is an introductory course covering key concepts of statistics and is taught by teachers from the Statistics department. It equips students with tools and skills required in analyzing data that are needed, in particular, in the practical courses and in research.

1. **Statistics:** Meaning and Scope; Variables and Attributes; Collection and Presentation of Statistical Data; Frequency Distribution and Graphical Representation.

   Intended learning outcomes: Enable the students to:
   - **(i)** Represent data in a statistical manner.
   - **(ii)** Tabulate data using frequency distribution and use it to find central tendency, mean, median and standard deviation.

2. **Analysis of Statistical Data:** Location; Dispersion and their Measures; Skewness; Kurtosis and their Measures; Moment and Cumulants.

   Intended learning outcomes: Enable the students to:
   - **(i)** Find whether a data is stretched or squeezed.
   - **(ii)** Measure the symmetry of a distribution and test the perfection of a sample data.

- **(iii)** Measure the kurtosis of a distribution.
- **(iv)** Understand moments and use it in physical calculations and definitions.

3. **Correlation and Regression:** Bivariate Data; Scatter Diagram, Marginal and Conditional Distributions; Correlation; Rank Correlation; Partial and Multiple Correlations; Contingency Analysis; Linear Regression for two Variables; Principle of Least Squares Method; Lines of Best Fit and Residual Analysis.

Intended learning outcomes: Enable the students to:

- **(i)** Demonstrate marginal and conditional distributions.
- **(ii)** Construct a graphical model using a sample data and use that model for solving problems.
- **(iii)** Compute Partial and Multiple Correlations.

Books Recommended

Text Books

Gupta, SC and Kapoor, VK	Fundamentals of Mathematical Statistics, 12th Edn.

Reference Books

Anderson, AJB	Interpreting Data
Yule, GU and Kendall, MG	An Intro to the Theory of Statistics, 14th Edn

PH1121 PHYSICAL MEASUREMENTS PRACTICAL (~56 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: ***50*** (*Continuous Assessment 15 marks, Attendance 5, Practical Exam 30 marks*)

(*1 day for Experiments*) *Examination duration:* ***6*** *hours*

In the beginning of the 1st Year B.Sc. (Honours) Laboratory work, students will have to undertake lessons on Basic measurements, Basic electricity, Curve plotting, Significant figures, Treatments of errors, etc. A total of 5 marks will be reserved for these items from the marks allotted for the continuous assessment. In the final exam, one experiment is to be performed in one day (six hours).

Prerequisite: HSC level theoretical and practical physics

List of Experiments

1. Determination of Young's Modulus of a Material by the Method of Bending.

Intended learning outcomes: Successful students should be able to:

- **(i)** Determine the Young's modules of the material of a bar by the method of bending.
- **(ii)** Demonstrate how the depression of a bar depends on the geometrical factions.
- **(iii)** Appreciate how physically measurable geometrical parameters can be related to intrinsic materiel property- elasticity.

2. Determination of Galvanometer Resistance.

Intended learning outcomes: Successful students should be able to:
- **(i)** Understand the construction and function of a galvanometer.
- **(ii)** Understand the role of shunt resistance in this experiment.

3. Determination of Galvanometer Constant (calculated current vs. Deflection curve is to be plotted).

Intended learning outcomes: Successful students should be able to:
- **(i)** Determine the galvanometer constant.
- **(ii)** Understand the link between galvanometer constant and galvanometer sensitivity.

Books Recommended

Text Books

Chawdhury, SA and Basak, AK	Byaboharik PadarthaVidya (*in Bangla*)
Ahmed, G and Uddin, MS	Practical Physics
Din, K	Practical Physics

Reference Books

Nelkon, M and Ogborn, JM	Advanced Level Practical Physics
Tyler, F	Laboratory Manual of Physics
Worsnop, BL and Flint, HT	Advanced Practical Physics
Topping, W	Errors of Observations

PH1122 MECHANICS PRACTICAL (~56 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: ***50*** (*Continuous Assessment 15 marks, Attendance 5, Practical Exam 30 marks*)

(*1 day for Experiments*) *Examination duration:* ***6*** *hours*

1. Determination of Moment of Inertia of a Flywheel.

Intended learning outcomes: Successful students should be able to:
- **(i)** Determine the moment of inertia of a flywheel.
- **(ii)** Link the concept of energy conversion in different forms with the concept of conservation of energy.
- **(iii)** Estimate the amount of friction and understand its role on the motion of the flywheel.

2. Determination of *g* by and *K* of a Compound Pendulum.

Intended learning outcomes: Successful students should be able to:
- **(i)** Determine the acceleration due to gravity and radius of gyration a compound pendulum.
- **(ii)** Demonstrate how the time–period of oscillation varies with the length between the point of suspension and the centre of mass.

3. Using a Flat Spring:

a) Verification of Hooke's Law and Hence Determination of Stiffness Constant;
b) Determination of g and the Effective Mass of the Spring.
c) Determination of Modulus of Rigidity of the Material of a Spring.

Intended learning outcomes: Successful students should be able to:

(i) Verify Hooke's law and determine stiffness constant, effective mass of spring, and modulus of rigidity of the material of the spring.
(ii) Understand the origin of effective mass of the spring.
(iii) Relate the geometrical factors with the stiffness constant.

4. Study of Two-Body Collisions in Two Dimensions.

Intended learning outcomes: Successful students should be able to:

(i) Determine frictional loss in collision in two dimensions.
(ii) Apply the principle of conservation of energy and momentum in collision problems.

Books Recommended

Text Books

Chawdhury, SA and Basak, AK	Byaboharik PadarthaVidya (*in Bangla*)
Ahmed, G and Uddin, MS	Practical Physics
Din, K	Practical Physics

Reference Books

Nelkon, M and Ogborn, JM	Advanced Level Practical Physics
Tyler, F	Laboratory Manual of Physics
Worsnop, BL and Flint, HT	Advanced Practical Physics
Topping, W	Errors of Observations

1st Year 2nd Semester

PH1201 PROPERTIES OF MATTER	(~28 contact hours)

Course Type: Core — *Credit Point: 2*

Full Marks: **50** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) — *Examination duration:* **2** *hours*

Prerequisites: Intermediate level vector algebra, mechanics and general physics.

Course Objectives and Summary: This is a basic course in physics to provide with an idea about the properties of matter like elasticity, surface tension, viscosity, etc.

1. **Mechanics of Elastic Media:** Elastic Constants and their Relationships; Theory of Bending Beams; Torsion of Cylinder; Flat and Non-flat Springs.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Calculate the amount of load to be borne by a cantilever.
   - **(ii)** Calculate the depressions of cantilever and beams and explain their uses in structural engineering.
   - **(iii)** Determine the effective mass of a spring.
   - **(iv)** Explain the impact of negative effective mass.
   - **(v)** Determine the modulus of rigidity of the materials.

2. **Surface Tension:** Molecular Phenomenon; Surface Energy; Curvature; Pressure and Surface Tension; Angle of Contact; Shape of Liquid Meniscus and Rise of Liquid in a Capillary Tube; Theory of Ripples and Problem of a Floating Needle.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Learn why some insects can float on the surface of water?
   - **(ii)** Calculate the angle of contact and explain the reasons for formation of obtuse and acute angles.
   - **(iii)** Distinguish between surface tension and surface energy.
   - **(iv)** Demonstrate the effect of adhesive and cohesive force.
   - **(v)** Calculate the pressure inside a bubble.

3. **Fluid Dynamics:** Streamline and Turbulent Flow; Equation of Continuity; Bernoulli's Equations and its Applications; Poiseuille's Equation for Fluid Flow; Stoke's Law – Measurement of Viscosity; Effects of Temperature and Pressure on Viscosity.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Differentiate between streamline and turbulent flow.
   - **(ii)** Learn the mechanism of congestion in water line.
   - **(iii)** Learn the mechanism of a sprayer.
   - **(iv)** Calculate the viscosity as a function of temperature.
   - **(v)** Demonstrate the working principle of viscometer.
   - **(vi)** Calculate the terminal velocity of a falling particle through a viscous fluid.

Books Recommended

Text Books

Mathur, DS	Elements of Properties of Matter
Newman, FH and Searle, VHL	General Properties of Matter
Champion, FC and Davy, N	Properties of Matter

Reference Books

Young, H, and Freedman, R	University Physics
Heuvelen, AV	Physics

PH1202 ELECTROMAGNETISM-II (~28 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: ***50*** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***2*** *hours*

Prerequisites: Concepts of electric charge, flow of charge through a medium, electric potential, electric field, production of e.m.f., Calculus, Basic Electricity and Magnetism

Course Objectives and Summary: This course delves into Electromagnetic Induction, covering Faraday's and Lenz's Laws, self and mutual induction, LR circuits, and the application of these principles in electric generators and motors. It extends to Magnetic Fields and Interactions, exploring forces on charge and current, Lorentz Force, and applications of Biot-Savart Law and Ampere's Law. Additionally, Thermoelectricity is examined, addressing thermoelectric phenomenon, power, diagrams, and thermocouples. The course provides a comprehensive understanding of electromagnetism, emphasizing theoretical principles and practical applications.

1. **Magnetic Fields and Interactions:** Magnetic Force on Charge and Current; Magnetic Effects of Current; Lorentz Force; Moving Coil Galvanometers: Dead Beat and Ballistic Galvanometer; Determination of Specific Charge of Electron; Analog Multimeter; Biot-Savart Law and its Applications; Ampere's Law and its Applications.

   Intended learning outcomes: Enable the successful students to:

   - **(i)** Calculate the amount of magnetic force on charge and current carrying conductors.
   - **(ii)** Explain the interaction of parallel and anti-parallel current.
   - **(iii)** Calculate magnetic field for general current distribution using Biot-Savart law.
   - **(iv)** Calculate magnetic field for symmetric current distribution using Ampere's law.
   - **(v)** Have practical knowledge while a current carrying coil is placed in magnetic field.

(vi) Convert galvanometer into an ammeter and a voltmeter.

2. **Electromagnetic Induction:** Faraday's and Lenz's Laws; Self and Mutual Induction; Growth and Decay of Current in LR Circuits; Charging and Discharging a Capacitor in RC Series Circuits; Time Constant and Natural Frequency; Concept of Electric Generator and Motors.

Intended learning outcomes: Enable the successful students to:

(i) Learn the mechanism of producing e.m.f. and the process of increasing it.
(ii) Find the direction of e.m.f. when a current-carrying conductor is placed in a magnetic field.
(iii) Calculate the self and mutual inductance induced in coils.
(iv) Explain the charging and discharging mechanisms of dc RC and RL circuits using the numerical values of current as a function of time.
(v) Calculate and visualize the growth and decay of currents in the above circuits.
(vi) Explain the operation of motor and generator.

3. **Thermoelectricity:** Thermoelectric Phenomenon and Relation; Thermoelectric Power; Thermoelectric Diagrams; Thermocouples.

Intended learning outcomes: Enable the successful students to:

(i) Learn the reason for production of e.m.f. due to temperature difference at the two junctions of two different kinds of metals.
(ii) Demonstrate the deficiency of Peltier effect that leads to Thomson effect.
(iii) Calculate thermoelectric power.
(iv) Describe the basics of thermoelectric generator.
(v) Construct thermopile and explain its effect in thermal measurements.

Books Recommended

Text Books

Halliday, D, Resnick and R, Walker	Fundamentals of Physics
Rafiqullah, AK et al.	Concepts of Electricity and Magnetism
Tewari, KK	Electricity and Magnetism
Islam, AKMA et al.	Tarit Chumbak Tatwa O Adhunik Padarthavijnan *(in Bangla)*
Theraja, BL	Text Book of Electrical Technology

Reference Books

Kip, A	Fundamentals of Electricity and Magnetism
Young, HD et al.	University Physics
Duffin, WJ	Electricity and Magnetism
Page, L and Adams, NI	Principles of Electrical Technology
Purcell, EM	Electricity and Magnetism
Agarwal, JP	Circuit Fundamentals and Basic Electronics
Griffiths, D	Introduction to Electrodynamics

PH1211 DIFFERENTIAL EQUATIONS (~28 contact hours)

Course Type: GEd *Credit Point: 2*

Full Marks: ***50*** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***2*** *hours*

Prerequisites: HSC level vector algebra and calculus.

Course Objective and Summary: Differential equations of various types and their solution methods are discussed in this course

1. **Basic Concepts:** Classification of Differential Equations, their Origin and Solutions; Initial-value Problems; Boundary-value Problems; Existence of Solutions.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Analyze boundary value problems and use this in number of physical problems.

2. **First Order Differential Equations:** Exact Differential Equations and Integrating Factors; Separable, Homogeneous and Linear Equations.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Solve exact differential equation.
   - **(ii)** Solve separable differential equation.

3. **Higher Order Linear Differential Equations:** Basic Theory of Linear Differential Equations; Homogeneous Linear Differential Equations with Constant Coefficients.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Demonstrate the basic theory of linear differential equations.
   - **(ii)** Solve homogeneous linear differential equations.

4. **Non-homogeneous Differential Equations:** Method of Undetermined Coefficients; Variation of Parameters.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Find a particular solution for inhomogeneous ordinary differential equations and recurrence relations.
   - **(ii)** Demonstrate the use of variation of parameters to solve inhomogeneous linear ordinary differential equations.

5. **Series Solutions of Linear Differential Equations:** Power Series Solutions about an Ordinary Point; Series Solutions about Regular Singular Points.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Solve linear differential equations using power series solutions.
   - **(ii)** Solve Hermite, Legendre and Bessel differential equations about regular singular points.

6. **Partial Differential Equations:** Some Basic Concepts.

   Intended learning outcomes: Enable the successful students to:

(i) Have some basic knowledge of partial differential equation.

Books Recommended

Text Books

Ross, SL	Differential Equations

Reference Books

Simmons, GF and Robertson, JS	Diff. Eqs. With Applications and Historical Notes
Arfken, GB	Mathematical Methods in Physics
Wong, CW	Introduction to Mathematical Physics

PH1212 INTEGRAL CALCULUS (~28 contact hours)

Course Type: GEd *Credit Point: 2*

Full Marks: **50** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* **2** *hours*

Prerequisites: HSC level calculus

Course Objective and Summary: Calculus is an important tool for a physicist. This is a generalized basic undergraduate mathematics course taught by teacher from the Mathematics department. It covers differential and integral calculus and provides students with skills and tools required in physics problems.

1. **Indefinite Integral:** Method of Substitutions; Integration by Parts; Special Trigonometric Functions and Rational Fractions.

   Intended learning outcomes: Enable the successful students to:
   (i) Evaluate the integration of a product by parts.
   (ii) Evaluate integration of trigonometric functions.
   (iii) Evaluate integration of rotational functions.

2. **Definite Integrals:** Fundamental Theorem; General Properties; Evaluations of Definite Integrals and Reduction Formulae.

   Intended learning outcomes: Enable the successful students to:
   (i) Evaluate definite integrals.
   (ii) Implement definite integration in calculating and analyzing number of physical problems, e.g., work, magnetic field, circuits, decay etc.

3. **Multiple Integrals:** Determination of Lengths, Areas and Volumes.

   Intended learning outcomes: Enable the successful students to:
   (i) Evaluate length, surface areas, and volumes using multiple integration.

Books Recommended

Text Books

Das, BC and Mukherjee, BN	Integral Calculus
Muhammad, K and Bhattacherjee, PK	Integral Calculus

Reference Books

Williamson, RE	Integral Calculus
Thomas and Finny	Calculus and Analytical Geometry
Swokowsky, E	Calculus and Analytical Geometry
Ayres, F	Calculus
Spiegel, MR	Schaum's Outline of Advanced Calculus

PH1213 ORGANIC CHEMISTRY (~28 contact hours)

Course Type: GEd *Credit Point: 2*

Full Marks: ***50*** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***2*** *hours*

Prerequisite: HSC level chemistry

Course Objective and Summary: Chemistry is a closely connected discipline to physics. There are significant areas of overlap and useful applications of chemistry concepts in the study of synthesis and properties of materials. This is a basic undergraduate course covering key concepts in inorganic and organic chemistry and is taught by teachers from the Chemistry department.

1. **Aliphatic Compounds:** Nomenclature of Organic Compounds; Preparation and Properties of Alcohols; Halides; Aldehydes; Ketones and Carbooxylic Acids; Coordination Compounds.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Find out the name of organic compound recommended by IUPAC.
   - **(ii)** Prepare and explain the properties of alcohols, halides, aldehydes, ketones and Carbooxylic Acids.
   - **(iii)** Demonstrate the use of Coordination Compounds in dying, electroplating, in identifying unknown substances in a liquid.

2. **Aromatic Compounds:** Aromaticity; Orientations; Preparations and Properties of Benzene; Phenol; Nitrobenzene and Aniline; Elementary Idea on Alicyclic and Heterocyclic Compounds.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Describe the preparation and explain the properties of Benzene, phenol, nitrobenzene and aniline.
   - **(ii)** Have basic knowledge of alicyclic and heterocyclic compounds.
   - **(iii)** Demonstrate the production and reactions of benzene.
   - **(iv)** Describe the health issue of benzene.

3. **Synthesis:** Synthesis Involving Grignard Reagent; Malonic Ester; Aceto-Acetic Ester and Diazonium Salts.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Describe the mechanism of different types of synthesis involving Grignard reagent, malonic ester and diazonium salt.
   - **(ii)** Demonstrate the use of diazonium in dye and pigment industry.

Books Recommended

Text Books

Ahmed, M &Jabbar, A	Organic Chemistry

Reference Books

Seberra, DK	Electronic Structure and Chemical Bonding

PH1214 PRINCIPLES OF STATISTICS-II (~28 contact hours)

Course Type: GEd *Credit Point: 2*

Full Marks: ***50*** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***2*** *hours*

Prerequisite: HSC level mathematics, PH1114

Course Objective and Summary: In the analysis of any type of data, statistical tools and concepts are essential. This is an introductory course covering key concepts of statistics and is taught by teachers from the Statistics department. It equips students with tools and skills required in analyzing data that are needed, in particular, in the practical courses and in research.

1. **Probability:** Concept of Probability; Sample Space; Events; Union and Intersection of Events; Probability of Events; Addition law of Probability; Conditional Probability; Multiplication law of Probability; Baye's Theorem.

   Intended learning outcomes: Enable the students to:
   - **(i)** Have the knowledge of probability.
   - **(ii)** Calculate union and intersection of events.
   - **(iii)** Use addition law and multiplication law of probability in solving problems.

2. **Random Variables and Probability Distribution:** Basic Concepts; Discrete and Continuous Random Variables; Density and Distribution Functions; Mathematical Expectation and Variance; Joint, Marginal and Conditional Density Functions; Conditional Expectation and Conditional Variance; Chebyshev's Inequality; Moments and Cumulant Generating Functions; Study of Binomial, Poisson and Normal Distributions.

   Intended learning outcomes: Enable the students to:

(i) Have the knowledge of discrete distribution and continuous distribution and use these to solve problems.
(ii) Calculate expected value of two random variables.
(iii) Use the concept of moments and Cumulant generating functions.

Books Recommended

Text Books

Cramer, H.	The Elements of Probability Theory
Gupta, S.C. and Kapoor, V.K.	Fundamentals of Applied Statistics, 3rdEdn.

Reference Books

Anderson, AJB	Interpreting Data
Mosteller, F., Rourke and Thomas	Probability with Statistical Appl., 2nd Edn.
Ross, S.M.	Introduction to Probability Models, 3rd Edn.
Yule, G. U. and Kendall, M. G.	An Intro.To the Theory of Statistics, 14th Edn.
Hoel, PG	Introduction to Probability Theory
Lipschutz, S	Probability

PH1215 SOLID GEOMETRY AND ALGEBRA (~42 contact hours)

Course Type: GEd *Credit Point: 3*

Full Marks: **75** (*Written Examination 52.5, In-course Evaluation 15 and Attendance 7.5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***3*** *hours*

Prerequisite: PH1112, Basic concepts of Matrix

Course Objectives and Summary: The course objective is to study coordinates, direction-cosines, shortest distance, sphere, cylinder, cone, theory of equations, inequalities, summation of algebraic series and complex numbers.

1. **Coordinates, Direction-cosines and Planes:** Projections, direction cosines, ratios, equations of planes, angle between two lines and planes, perpendicular distance of a point from a plane.

   Intended learning outcomes: Enable the students to:
   (i) Calculate direction-cosines,
   (ii) Calculate the angles between two lines and planes.
2. **Straight lines and Shortest distance:** General and symmetrical form of equation, coplanar, conditions for a line to line in a plane and shortest distance and equation.

   Intended learning outcomes: Enable the students to:
   (i) Explain the symmetrical form of equation.
   (ii) Calculate the shortest distance.
3. **Sphere, Cylinder and Cone:** General equations of sphere, cylinder and cone, coaxial sphere, great circle, right circular cylinder, enveloping cylinder, reciprocal cone, cone with given vertex and base.

Intended learning outcomes: Enable the students to:
- **(i)** Derive equations of sphere, cylinder and cone.
- **(ii)** Explain coaxial sphere, great circle, and reciprocal cone.

4. **Theory of equations:** Fundamental theorem of algebra, Relation between roots and coefficients, Descartes rule of signs. Nature of the roots, formation of equations when roots are given, solution of cubic equations.

Intended learning outcomes: Enable the students to:
- **(i)** Explain fundamental theorem of algebra.
- **(ii)** Solve cubic equations.

5. **Inequalities:** Arithmetic, Geometric and Harmonic mean, Weierstrass, Cauchy's and Chebyshev's inequalities.

Intended learning outcomes: Enable the students to:
- **(i)** Calculate arithmetic, geometric and harmonic mean.
- **(ii)** Explain Cauchy's and Chebyshev's inequalities.

6. **Summation of Algebraic Series:** Summation by the method of difference, Summation by the method of finite difference, Summation of the series in which is a product of r factors in A.P., generating function of the recurring series, sum of n terms of a recurring series.

Intended learning outcomes: Enable the students to:
- **(i)** Perform summation by the method of difference.
- **(ii)** Perform summation of n terms of a recurring series.

7. **Complex numbers:** Complex number and its geometrical representation, modulus and amplitude, addition and multiplication of complex quantities, functions of complex arguments, periodicity of circular and exponential functions, logarithm of a complex quantity, inverse circular functions of complex arguments. De Moivre's theorem and its applications.

Intended learning outcomes: Enable the students to:
- **(i)** Represent, sum and multiply complex numbers.
- **(ii)** Explain and apply De Moivre's theorem.

Books Recommended

Text Books

Askwith, HH	Analytic Geometry of Conic Sections
Bell, JT	A Treatise on Three Dimensional Geometry
Smith, C	A Treatise on Threse Dimensional Geometry
Hall and Knight	Higher Algebra
Bernard and Child	Higher Algebra

Reference Books

Kar, JM	Analytic Geometry of Conic Sections
Smith, C	Analytic Geometry of Conic Sections

PH1221 PROPERTIES OF MATTER PRACTICAL (~56 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: **50** (*Continuous Assessment 15 marks, Attendance 5, Practical Exam 30 marks*)

(*1 day for Experiments*) *Examination duration:* **6** *hours*

List of Experiments

1. Determination of Young's Modulus of a Material by the Method of Bending.

Intended learning outcomes: Successful students should be able to:
- **(i)** Determine the Young's modules of the material of a bar by the method of bending.
- **(ii)** Demonstrate how the depression of a bar depends on the geometrical factions.
- **(iii)** Appreciate how physically measurable geometrical parameters can be related to intrinsic materiel property- elasticity.

2. Determination of Rigidity Modulus of a Material by the Statical Method.

Intended learning outcomes: Successful students should be able to:
- **(i)** Determine rigidity modules by statical method.
- **(ii)** Relate geometrical factors and angle of twist to the rigidity modulus.

3. Determination of Elastic Constants (Y, n, K and σ) of the Material of a Wire by Searle's Method.

Intended learning outcomes: Successful students should be able to:
- **(i)** Calculate various elastic parameters and establish relations among them.

4. Determination of the Surface Tension of Water by Capillary Rise Method ($1/r$ versus h curve is to be plotted).

Intended learning outcomes: Successful students should be able to:
- **(i)** Determine surface tension from the capillary effect of a liquid in a fine tube.
- **(ii)** Understand the role of cohesive and adhesive forces behind the observed phenomenon.

5. Determination of the Surface Tension and Angle of Contact of Mercury by Quincke's Method.

Intended learning outcomes: Successful students should be able to:
- **(i)** Determine the surface tension of mercury and angle of contact of mercury – glass system.
- **(ii)** Understand the role of various energies in determining the shape of the mercury drop on the glass plate.

6. Determination of the Surface Tension of a Liquid by the Method of Ripples.

Intended learning outcomes: Successful students should be able to:
- **(i)** Determine the surface tension of a liquid from the ripple parameters.
- **(ii)** Understand the waves in liquids controlled by gravity and surface tension.

7. Determination of Viscosity of Water by Capillary Flow Method.

Intended learning outcomes: Successful students should be able to:
- **(i)** Determine viscosity of a liquid from the capillary flow rate.
- **(ii)** Explain the principle of a capillary flow viscometer.

Books Recommended

Text Books

Chawdhury, SA and Basak, AK	Byaboharik PadarthaVidya (*in Bangla*)
Ahmed, G and Uddin, MS	Practical Physics
Din, K	Practical Physics

Reference Books

Nelkon, M and Ogborn, JM	Advanced Level Practical Physics
Tyler, F	Laboratory Manual of Physics
Worsnop, BL and Flint, HT	Advanced Practical Physics
Topping, W	Errors of Observations

PH1222 ELECTROMAGNETISM PRACTICAL (~56 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: ***50*** (*Continuous Assessment 15 marks, Attendance 5, Practical Exam 30 marks*)

(*1 day for Experiments*) *Examination duration:* ***6*** *hours*

List of Experiments

1. Determination of Specific Resistance of a Wire by Wheatstone's Bridge with End Corrections.

Intended learning outcomes: Successful students should be able to:

(i) Understand the different sources of end-corrections and their sign.
(ii) Determine the end-corrections and use those in determining the resistance of a sample.

2. Measurement of Low Resistance by the Method of Fall of Potential.

Intended learning outcomes: Successful students should be able to:

(i) Determine low-resistance with a meter bridge.
(ii) Understand the concept of electric potential and drop of electric potential in a circuit.

3. Investigation of the Relation between the Current and Voltage for a Tungsten and a Carbon Filament Lamp.

Intended learning outcomes: Successful students should be able to:

(i) Differentiate between the temperature dependent resistivity of metal and semi conduction.
(ii) Understand the origin of non-linear relation between current and voltage.

4. Calibration of a Meter Bridge.

Intended learning outcomes: Successful students should be able to:

(i) Understand the importance of calibration.
(ii) Calibrate the meter bridge wire.

Books Recommended

Text Books

Chawdhury, SA and Basak, AK	Byaboharik PadarthaVidya (*in Bangla*)
Ahmed, G and Uddin, MS	Practical Physics
Din, K	Practical Physics

Reference Books

Nelkon, M and Ogborn, JM	Advanced Level Practical Physics
Tyler, F	Laboratory Manual of Physics
Worsnop, BL and Flint, HT	Advanced Practical Physics
Topping, W	Errors of Observations

2nd Year 1st Semester

PH2101 OPTICS	(~28 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: ***50*** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***2*** *hours*

Prerequisite: Basics of intermediate level knowledge about all aspects of light

Course Objectives and Summary: The course objective is to study the concepts of electromagnetic waves including dual nature of light, and their propagation in a medium, the optical phenomena such as interference, diffraction and polarization.

1. **Light and Images:** Huygen's Principle; Fermat's Principle; Ray Matrix Method; Dispersion; Aberrations in Optical Images.

   Intended learning outcomes: Enable the students to:
   - **(i)** Learn what does light mean.
   - **(ii)** Represent pictorially the electromagnetic spectrum/spectra.
   - **(iii)** Know pictorial representation of wavelet, wave-front and propagation of wave-front, refractive index, total internal reflection.
   - **(iv)** Calculate the least time required to propagate a light wave through a medium.
   - **(v)** Draw the figures to demonstrate the effect of various aberrations using incident and reflected waves.
   - **(vi)** Mechanism of photography and optical vision.

2. **Interference:** Superposition of Waves; Concept of Coherence; Types of Interference; Wavefront Division Interference: Young's Experiment, Bi-prism; Amplitude Division Interference: Thin Film Interference, Newton's Rings, Fabry-Perot Interferometer, Michelson's Interferometer.

   Intended learning outcomes: Enable the students to:
   - **(i)** Understand the result of the overlapping of two or more waves
   - **(ii)** And formation of maxima and minima in the resultant wave using graphical representation.
   - **(iii)** Learn different ways of formation of coherent sources.
   - **(iv)** Derive the equations for interference and hence find out the conditions for constructive and destructive interference.
   - **(v)** Calculate the wavelength of light and the thickness of a film.

3. **Diffraction:** Types of Diffraction; Fraunhofer Diffraction; Single, Double and Multiple Slits Diffraction; Grating; Resolving Power of Grating; Rayleigh Criteria; Fresnel Diffraction; Zone Plate, Diffraction by a Circular Aperture, Diffraction by a Narrow Slit, Cornu's Spiral, Fresnel's Integral.

   Intended learning outcomes: Enable the students to:
   - **(i)** Differentiate between interference and diffraction.
   - **(ii)** Effect of sources at finite and infinite distances.
   - **(iii)** Production of diffraction pattern using diffraction grating.

(iv) Know why and how the diffraction pattern arises on the both sides of the central maximum.
(v) Know the condition of diffraction for a particular wavelength of light through a particular slit.
(vi) Use the Fresnel' integral in describing Fresnel diffraction.

4. **Polarization:** Types of Polarization; Production and Detection of Polarization; Brewster's Law; Malus' Law; Nicol Prism; Optical Activity; Fresnel's Theory of Optical Rotation; Polarimeter.

Intended learning outcomes: Enable the students to:
(i) Know the mechanism of polarization of light.
(ii) Differentiate among plane polarized, circularly polarized and elliptically polarized light (pictorial representations are essential).
(iii) Differentiate between optically active and inactive substances.
(iv) Calculate the optical rotation in a material medium.
(v) Determine the amount of solute in a solvent.

Books Recommended

Text Books

Hecht, E	Optics
Jenkins, FA and White, HE	Principles of Optics
Ghatak, A	Optics

Reference Books

Meyer-Arendt, JR	Introduction to Classical & Modern Optics
Heavens, OS and Ditchburn, RW	Insight Into. Optics*Pedrotti,*
Brijlal, L	A Text Book of Optics
Longhurst, RS	Geometrical & Physical Optics
Sladkova, J	Interference of Light
Arnold, RG	Electronic Devices
Hamam, S	Principles of Light Optics
Born, M and Wolf, E	Principles of Optics
Peatross, J and Ware, M	Physics of Light and Optics
Pedrotti, FL, Pedrotti LM and Pedrotti, LS	Introduction to Optics

PH2102 HEAT AND RADIATION (~28 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: ***50*** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***2*** *hours*

Prerequisite: HSC level physics

Course Objective and Summary: This is a fundamental undergraduate course in physics designed to develop an in-depth knowledge of heat and radiation and to use this knowledge to explore various applications. Concepts of temperature, temperature measurement techniques, transport phenomena in the light of kinetic theory of gases and various laws of black body radiation are taught in this course.

1. **Temperature:** Macroscopic and Microscopic Views; Thermal Equilibrium and Zeroth Law; Temperature Concept; Principles of Measurement and Establishment of Temperature Scales; Absolute Scale; International Scale; Gas Thermometer; Electrical Resistance Thermometer; Thermocouple.

   Intended learning outcomes: Enable the students to:
   - **(i)** Learn different temperature scales and their conversion.
   - **(ii)** Measure unknown temperatures with different types of thermometers.
   - **(iii)** Demonstrate the use of Thermocouple for different temperature measurements.

2. **Kinetic Theory of Gases and Transport Phenomenon:** Basic Assumptions; Equation of State of an Ideal Gas; Concept of Pressure and Temperature; Brownian Motion; Equipartition of Energy; Real Gases and Intermolecular Forces; Van der Waal's Equation of State; Collision Cross-Section; Mean Free Path; Thermal Conductivity; Coefficient of viscosity; Diffusion.

   Intended learning outcomes: Enable the students to:
   - **(i)** Comprehend physical basis of the kinetic theory of gases.
   - **(ii)** Calculate the pressure exerted by a gas.
   - **(iii)** Apply equipartition theorem to derive the ideal gas law and Dulong-Petit law for the specific heat capacities of solid.
   - **(iv)** Learn physical basis of the Van der Waal's equation apply it to real gases.
   - **(v)** Calculate viscosity and thermal conductivity of gases using kinetic theory.

3. **Radiation:** Theory of Exchange; Kirchhoff's Law; Nernst Black-Body Radiation; Stefan-Boltzmann's Law; Rayleigh-Jean's Law; Wien's Radiation Law; Planck's Quantum Law.

   Intended learning outcomes: Enable the students to:
   - **(i)** Understand the concept of blackbody radiation.
   - **(ii)** Explain some important astrophysical phenomena applying Kirchhoff's law.
   - **(iii)** Calculate the energy radiated by a body at a given temperature using Stefan-Boltzmann law.
   - **(iv)** Calculate the peak wavelength of radiation of a given body at a given temperature using Wien's law.
   - **(v)** Understand Planck's radiation law.

Books Recommended

Text Books

Zemansky, MW	Heat and Thermodynamics
Sears, FW and Salinger, GL	Thermodynamics: Kinetic Theory and Statistical Mechanics
Finn, CBP	Thermal Physics
Hossain, T	Text Book on Heat

Saha, MN and Srivastava, BK	A Treatise on Heat

Reference Books

Roberts, JK and Miller, AR	Heat and Thermodynamics
Reif, F	Fundamentals of Thermal Physics
Schroeder	Introduction to Thermal Physics
Brijlal, Subrahmanyam, Hemne	Heat, Thermodynamics and Statistical Physics

PH2103 CLASSICAL MECHANICS-I (~28 *contact hours)*

Course Type: Core *Credit Point: 2*

Full Marks: ***50*** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* **2** *hours*

Prerequisites: PH1101, PH1112, PH1211, PH1212

Course Objectives and Summary: Classical mechanics describes constrained motion, generalized coordinates, variational principle, cyclic coordinates, Lagrangian formulation etc. Two-body central force problems are treated in the center of mass coordinate systems. Scattering problems and shapes of orbits are also discussed.

1. **Motion in Configuration Space:** Degrees of Freedom, Constraints and Generalized Coordinates; Configuration Space; Principle of Virtual Work; D'Alembert's Principle and Lagrange's Equations of Motion; Nonuniqueness of the Lagrangian; Symmetry of Lagrangian; Invariance of the Lagrange equations, Lagrange's Equations for Velocity Dependent and Nonpotential forces.

   Intended learning outcomes: Enable the students to:
   - **(i)** Understand different types of constraints and generalized coordinates.
   - **(ii)** Use the generalized coordinates to model and solve a problem.
   - **(iii)** Understand the principle of virtual work and evaluate the equilibrium(s) in basic structural engineering.
   - **(iv)** Model and solve problems using Lagrangian formulation for both holonomic and non-holonomic systems.

2. **Variational Principles and Lagrange's Equations:** The Calculus of variations-Stationary Points and Stationary Paths. Euler's Equations; Geodesics, Brachistrochrone; Hamilton's Principle; Lagrange's Equations from Hamilton's Principle; Extension of Hamilton's Principle to systems with Constraints; Physical Interpretation of the Lagrange Multipliers; Cyclic Coordinate and Generalized Momentum; Conservation Theorem and Symmetry Properties.

   Intended learning outcomes: Enable the students to:
   - **(i)** Calculate the shortest distance between two points, minimum surface of revolution etc. using calculus of variation.
   - **(ii)** Explain symmetry and its relation to the conservation laws.

3. **Two-Body Central Force Problem:** Definition and Characteristics of Central Force; Reduction to One-Body Problem; The Equations of Motion and First Integrals; The Equivalent One-Dimensional Problem and Classification of Orbits; The Differential Equation for the Orbit and Integral Power-Law Potentials; The Kepler Problem: Inverse-Square Law of Force; Scattering in a Central Force Field; Center of Mass and Laboratory Coordinate Systems; Elastic Scattering Problem in Laboratory and Center of Mass Systems.

Intended learning outcomes: Enable the students to:

- **(i)** Explain central force, center of mass and laboratory coordinate systems.
- **(ii)** Reduce to equivalent one body problem.
- **(iii)** Explain the details of orbits and evaluate the eccentricity, and stability of orbits.
- **(iv)** Explain elastic scattering both in laboratory and center of mass systems and calculate the scattering cross-section.

Books Recommended

Text Books

Goldstein, G	Classical Mechanics
Hamill, P	A student's guide to Lagrangians and Hamiltonians
Tai L Chow	Classical Mechanics
Taylor, JR	Classical Mechanics
Greiner, W	Classical Mechanics
Morin, D	Introduction to Classical Mechanics

Reference Books

Constant, FW	Theoretical Physics
Rana, NC and Joag, PS	Classical Mechanics
Spiegel, MR	Theoretical Mechanics
Gupta, Sl et al	Classical Mechanics
Gupta, KC	Mechanics of Particle & Rigid Bodies
Leech, JW	Classical Mechanics
Louis, NH and Janet, DF	Analytical Mechanics
Harun-or Rashid, AM	Chirayata Balavidya *(in Bangla)*
Biswas, SN	Classical Mechanics
Gregory, RD	Classical Mechanics
Hund and Finch	Analytical Mechanics

PH2111 PHYSICAL CHEMISTRY (~42 contact hours)

Course Type: GEd *Credit Point: 3*

Full Marks: **75** (*Written Examination 52.5, In-course Evaluation 15 and Attendance 7.5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* **3** *hours*

Prerequisites: HSC level physical chemistry

Course Objective and Summary: Chemistry is a closely connected discipline to physics. There are significant areas of overlap and useful applications of chemistry concepts in the study of synthesis and properties of materials. This is a basic undergraduate course covering key concepts in physical chemistry and is taught by teachers from the Chemistry department.

1. **Chemical Equilibria:** Law of Mass Action; Thermodynamic Derivation of Law of Mass Action; Effects of Temperature; Pressure and Concentration on Chemical Equilibria; Relationship between K_P, K_C and K_X; Temperature Dependence of Equilibrium Constant.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Predict the dependency of chemical reaction on mass of reactants derive the law of mass action.
   - **(ii)** Know how do the pressure, temperature and concentration shift the chemical equilibria toward reactants or products and write specific chemical reactions as examples.
   - **(iii)** Determine exothermic and endothermic reactions.
   - **(iv)** Relate the affinity constants.

2. **Chemical Kinetics:** Order and Molecularity; Rate Equations for First and Second Order Reactions; Determination of Order of Reactions; Arrhenius Equation and Energy of Activation; Collision Theory; Catalysis: Definition, Characteristics, Promoter and Poisoning, Classification; Theory of Catalysis; Industrial Examples of Catalysis.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Link the reaction rate with concentrations or pressures of reactants and constant parameters
   - **(ii)** Demonstrate the raise of concentration term in rate equation.
   - **(iii)** Explain the temperature dependence of reaction rate calculate the energy of activation.
   - **(iv)** Demonstrate the increase in the rate of a chemical reaction due to the participation of catalysis.

3. **Surface Chemistry and Colloids:** Adsorption; Langmuir Adsorption Isotherm; Determination of Surface Area; Colloids – Classification; Preparation; Purification; Properties and Importance; Elementary Ideas about Emulsion and Gels.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Explain the adhesion of atoms, ions, or molecules from a gas, liquid, or dissolved solid to a surface.
   - **(ii)** Demonstrate the use of emulsion in food, health, synthesis.
   - **(iii)** Demonstrate the preparation and use of colloids.

4. **Electrolytic Dissociation:** Arrhenius Theory of Electrolytic Dissociation; Electrolytes and their Classifications; Transport Number and its Determination; Ostwald's Dilution Law; Solubility and Solubility Products; Common Ion Effect.

Intended learning outcomes: Enable the successful students to:

- **(i)** Demonstrate the separation of dissolved electrolytes into cations and anions.
- **(ii)** Describe the degree of dissociation of weak electrolyte.
- **(iii)** Explain the reduction in the solubility of an ionic precipitate when a soluble compound containing one of the ions of the precipitate is added to the solution in equilibrium with the precipitate.

5. **Electrolysis and Electrical Conductance**: Electrolysis; Faraday's Law of Electrolysis; Physical Significances of Chemical Equivalent and Electrochemical Equivalent; Conductance of Electrolytes: Specific Conductance and Equivalent Conductance, Variation of Electrical Conductance with Concentration and Temperature; Measurement of Equivalent Conductance: Conductance Cell, Cell constant Kohlrausch's Law of Independent Migration of Ions; Applications of Conductance Measurement.

Intended learning outcomes: Enable the successful students to:

- **(i)** Demonstrate the separation of elements from naturally occurring sources such as ores using an electrolytic cell.
- **(ii)** Measure the ionic content in a solution by measuring conductivity of electrolyte.
- **(iii)** Demonstrate the measurement of product conductivity is a typical way to monitor and continuously trend the performance of water purification systems.

6. **Acid and Bases:** Definitions of Acid and Bases According to Arrhenius, Browsted-Lowry, and Lewis; Frankline and Lux-flood Concepts; Neutralization Reactions; Strength of Acid and Bases: pH, pOH, pK_a, pK_b, pK_w; Measurement of pH of a Buffer Solution; Indicators and Acid-Base Titration Curves; Hydrolysis of Salts and pH of Salt Solutions.

Intended learning outcomes: Enable the successful students to:

- **(i)** Define acid and base according to Arrhenius.
- **(ii)** Demonstrate the ability of acids to "donate" hydrogen ions (H^+) and ability of bases to "accept" them.
- **(iii)** Describe the chemical reaction in which an acid and a base react quantitatively with each other.
- **(iv)** Able to measure pH.

Books Recommended

Text Books

Lewis, D and Glasstone, S	Elements of Physical Chemistry
Glasstone, S	Physical Chemistry
Rakshit, PC	Physical Chemistry
Haque, MM and Nawab, MA	Principles of Physical Chemistry
Palit, SR	Elementary Physical Chemistry
Barrow, GM	Physical Chemistry
Pal, SC and Chakraborty, PK	Snatak Vouta Rasayan *(in Bangla)*
Bahl, BS, Tuli, GD and Bahl, A	Essential of Physical Chemistry

PH 2112 NUMERICAL METHODS (~42 hours)

Course Type: GEd *Credit Point: 3*

Full Marks: **75** (*Written Examination 52.5, In-course Evaluation 15 and Attendance 7.5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***3*** *hours*

Prerequisites: PH1112, PH1211, PH1212

Course Objectives and Summary: This course is designed to provide knowledge of some numerical techniques applicable to solve various mathematical problems.

1. **Transcendental Equations:** Numbers and their Accuracy; Error Analysis; Intermediate Value Theorem; Iteration Methods: Bisection Method, Iterative Method, False-Position Method, Newton-Raphson Method.

   Intended learning outcomes: Enable the students to:
   - **(i)** Differentiate (a) iterative and direct methods and (b) transcendental and polynomial equations.
   - **(ii)** Apply iterative methods (bisection, Newton-Raphson, iterative, false-position) to solve transcendental and linear equations.

2. **System of Linear Equations:** Matrix Representation; Basic Matrix Operations; Direct Methods- Matrix Inversion; Gauss Elimination Methods; Gauss-Jordon Method; Triangularization Method; Iterative Methods: Jacobi Method, Gauss-Seidel Method.

   Intended learning outcomes: Enable the students to:
   - **(i)** Apply the above direct and iterative methods to solve a system of linear equations.

3. **Eigenvalues and Eigenvectors:** Eigenvalue Equation; Power Method; Jacobi Method; Givens Method.

   Intended learning outcomes: Enable the students to:
   - **(i)** Apply the above methods to find out eigenvalues and eigenvectors of square matrices.

4. **Interpolation and Curve Fitting:** Newton's Forward and Backward Difference Interpolation Formula; Hermite and Lagrange's Interpolation Formula; Spline Interpolation; Linear and Polynomial Least Squares Curve Fitting.

   Intended learning outcomes: Enable the students to:
   - **(i)** Explain finite divided differences.
   - **(ii)** Derive Newton's divided difference formula and use it to find missing data, such as population, laboratory data, and predict the behavior of a graph of no data region.
   - **(iii)** Construct a simple model of desired accuracy for a particular limit for engineering or research purpose from a sophisticated data.

5. **Numerical Differentiation and Integration:** Numerical Differentiation using Interpolation; Numerical Integration: Trapezoidal Method; Simpson's Method; Errors in these Methods; Romberg Method.

   Intended learning outcomes: Enable the students to:
   (i) Find derivatives using interpolation.
   (ii) Do integration using Trapezoidal rule, Simpson's rules.
   (iii) Find the cross-section of a river, force due to non-uniform wind flow, heat flux etc.

6. **Ordinary Differential Equations:** Solution by Taylor Series; Euler's Method; Runge-Kutta Methods; Predictor-Corrector Methods: Adams-Moulton; Milne-Simpson.

   Intended learning outcomes: Enable the students to:
   (i) Solve ordinary differential equation by Taylor series, Euler's method, Runge-Kutta methods.

Books Recommended

Text Books

Sastry, SS	Introductory Methods of Numerical Analysis
Jain, MK, Iyengar and Jain	Numerical Methods for Sci & Engg Computation
Chapra, S and Canale, R	Numerical Methods for Engineering

Reference Books

Hamming, RW	Numer. Methods for Scientists and Engineers
Scheid, F	Introduction to Numerical Analysis.
Scarborough, JB	Numerical Mathematical Analysis
Carnahan, B, et al	Applied Numerical Methods
Ralston, A and Robinowitz, P	First Course in Numerical Analysis
Rajaraman, V	Numerical Analysis

PH2113 COMPUTATION AND PROGRAMMING (~ 42 *contact hours)*

Course Type: GEd *Credit Point: 3*

Full Marks: **75** (*Written Examination 52.5, In-course Evaluation 15 and Attendance 7.5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* **3** *hours*

Prerequisites: HSC level ICT

Course Objectives and Summary: This course aims to equip the students to be able to use Fortran/C++/Python to address simple scientific problems. It also introduces symbolic scientific computation with Mathematica/Matlab/Maple. Thus this course intends to provide a foundation of a range of computational tools that a student may require at more advanced levels of study and research.

1. **Computer Programming:** Introduction to High-Level Languages; Steps in Programming: Algorithm and Flowchart, Sequential Executions, Branching Operations, Looping Operations, Procedures, Comments, Errors and Debugging. Programming [To be taught based on either Fortran or Python with an introduction to the other one and C++]: Data Types, Arithmetic Statements, Loops and Logical Expressions, Arrays, Functions and Subroutines, Formatted Input/Output, File Processing, Applications to Various Statistical and Physical Problems.

   Intended learning outcomes: Enable the students to:
   - **(i)** Write algorithms and flowcharts to solve relevant problems.
   - **(ii)** Write the corresponding programs in Fortran / python / C++.
   - **(iii)** Debug the source code for errors.

2. **Symbolic Scientific Computing:** Data Input/Import, Data Transformation, Solution of Equations, Integrations, Matrix Operations, Visualization [Suitable software from options such as Matlab, Mathematica, Octave etc.].

   Intended learning outcomes: Enable the students to:
   - **(i)** Transform data.
   - **(ii)** Perform solutions of equations, integration, and matrix operations using computer program.
   - **(iii)** Produce suitable plots.
   - **(iv)** Solve mathematical problems using suitable software.

Books Recommended

Text Books

Chapman, SJ	Introduction to Fortran 90/95
Rajaraman, V	Computer Programming in Fortran 90 and 95
Mathes, E	Python Crash Course
Hubbard	Programming with C++

Reference Books

Metcalf, M, Reid, J and Cohen, M	Modern Fortran Explained
Nyhoff, L and Leestma, S	Fortran 90 for Scientists and Engineers
Swiegart, A	Automate the Boring Stuff with Python
তামমি শাহরয়িার সুবনি	পাইথন দয়িে প্রোগ্রামংি শখো (১ম-৪র্থ খণ্ড)
মাকসুদুর রহমান মাটনি	সহজ ভাষায় পাইথন ৩
Schildt, H	Turbo C/C++

PH2121 HEAT AND RADIATION PRACTICAL (~56 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: **50** (*Continuous Assessment 15 marks, Attendance 5, Practical Exam 30 marks*)

(*1 day for Experiments*) *Examination duration:* ***6*** *hours*

Prerequisites: PH 2102

List of Experiments

1. Determination of Specific Heat of Solid with Radiation Correction.

   Intended learning outcomes: Successful students should be able to:
   - **(i)** Define specific heat, thermal capacity and water equivalent.
   - **(ii)** Use calorimeter.
   - **(iii)** Understand Newton's law of cooling.
   - **(iv)** Name the factors on which the radiation of heat depends.

2. Determination of Thermal Conductivity of a Bad Conductor.

   Intended learning outcomes: Successful students should be able to:
   - **(i)** Define thermal conductivity, temperature gradient, area of cross section.
   - **(ii)** Explain Newton's law of cooling.
   - **(iii)** Dev Name the processes by which heat can flow.
   - **(iv)** Name the factors on which the radiation of heat depends.

3. Calibration of a Thermocouple and Determination of Unknown Temperature.

   Intended learning outcomes: Successful students should be able to:
   - **(i)** Use the potentiometer, draw the calibration cure, and measure an unknown temperature using the curve.

4. Determination of the Ratio of the Specific Heats of a Gas by Clement and Desorme's Apparatus.

   Intended learning outcomes: Successful students should be able to:
   - **(i)** Use the Clement and Desorme's apparatus.
   - **(ii)** Relate the specific heats with the barometric height.

5. Determination of *J* by Callendar and Barnes Apparatus (with radiation correction).

   Intended learning outcomes: Successful students should be able to:
   - **(i)** Use Callendar and Barnes apparatus.
   - **(ii)** Calculate electric energy transformed in the heating element.
   - **(iii)** Explain the meaning of *J*.

Books Recommended

Chawdhury, SA and Basak, AK	Byaboharik Padarthvidya*(in Bangla)*
Ahmed, G and Uddin, MS	Practical Physics
Nelkon, M and Ogborn, JM	Advanced Level Practical Physics
Tyler, F	Laboratory Manual of Physics
Worsnop, BL and Flint, HT	Advanced Practical Physics
Din, K and Matin, MA	Advanced Practical Physics

PH2122 ELECTRONICS AND ELECTRICITY PRACTICAL (~56 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: ***50*** (*Continuous Assessment 15 marks, Attendance 5, Practical Exam 30 marks*)
(*1 day for Experiments*) *Examination duration:* ***6*** *hours*
Prerequisites: HSC Physics 2nd Paper, PH 1111

List of Experiments

1. To Study the Variation of Reactances due to *L* and *C* with Frequencies and Hence Find the Condition of Resonance from the (*X-f*) Curves.

   Intended learning outcomes: Successful students should be able to:
   (i) Show the relation between frequency and reactance mathematically as well as graphically.
   (ii) Find out the resonance condition.
   (iii) Differentiate between ohmic and reactive resistances.

2. Determination of Resonant Frequency in *LCR* Circuits with: a) *L* and *C* in Series, b) *L* and *C* in Parallel.

   Intended learning outcomes: Successful students should be able to:
   (i) Show the relation between voltage/current/impedance and frequency.
   (ii) Find out the resonance frequency.
   (iii) Find out the Q-factor of a curve.

3. To Study the Characteristics of a *p-n* Junction Diode and hence to Determine its Dynamic Resistance.

   Intended learning outcomes: Successful students should be able to:
   (i) Draw the characteristic curve of a p-n junction.
   (ii) Show the knee voltage.
   (iii) Calculate dynamic resistance.

4. To Study the Characteristics of a Zener Diode and Its Use in a Voltage Regulator.

   Intended learning outcomes: Successful students should be able to:
   (i) Regulate voltage.
   (ii) Explain the Zener characteristics.

5. Phasor Diagram of Voltages in an AC Circuit Containing *L*, *C* and *R* and Study of the Variation of Phases with Frequency.

   Intended learning outcomes: Successful students should be able to:
   (i) Represent graphically the directions of VL, VC and VR in an AC circuit.

Books Recommended

Chawdhury, SA and Basak, AK	Byaboharik Padarthvidya *(in Bangla)*
Ahmed, G and Uddin, MS	Practical Physics
Nelkon, M and Ogborn, JM	Advanced Level Practical Physics
Tyler, F	Laboratory Manual of Physics
Worsnop, BL and Flint, HT	Advanced Practical Physics
Din, K and Matin, MA	Advanced Practical Physics

2nd Year 2nd Semester

PH2201 NONLINEAR AND FIBRE OPTICS	(~28 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: **50** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* **2** *hours*

Prerequisites: PH2101

Course Objectives and Summary: The course objective is to study lasers, nonlinear optical phenomena and fiber optics communication. It also provides a basis for further study in optoelectronics.

7. **Lasers:** Fundamental Emission and Absorption Processes in Atoms; Radiative Transitions; Einstein's Co-efficients; Light Amplification; Production of Population Inversion; Threshold Condition for Lasing Action; Types of Lasers; Characteristics and Applications of Laser, Basic Concepts of Holography: Construction and Deconstruction.

   Intended learning outcomes: Enable the students to:
   - **(i)** Explain creation of population of inversion.
   - **(ii)** Demonstrate the formation of resonator cavity.
   - **(iii)** Know the process of generation of new wavelength of light.
   - **(iv)** Explain the beam profile.

2. **Nonlinear optics:** Nonlinear polarization, Harmonic generation, Phase matching, Nonlinear optical susceptibilities, Nonlinear optical materials, Nonlinear refraction and absorption, Two photon absorption, Third order nonlinearity measurement techniques: Z-scan.

   Intended learning outcomes: Enable the students to:
   - **(i)** Explain the nonlinear response of the material.
   - **(ii)** Demonstrate self-focusing and defocusing phenomena.
   - **(iii)** Apply two photon absorption concepts to measure nonlinearity through Z-scan technique.

3. **Fibre Optics:** Graded Index (GRIN) Lens; Theory of Refractive Gradients; Fibre Optics; Ray Transmission; Basic Terms in Fibre Optics; Modes in Optical Fibre; Fibre Bundles; Loss Mechanisms; Dispersion in Optical Fibre.

   Intended learning outcomes: Enable the students to:
   - **(i)** Explain the propagation of light through optical fibre.
   - **(ii)** Explain the refractive index profile of optical fibre.
   - **(iii)** Explain different modes involved in optical fibre.
   - **(iv)** Calculate the signal loss in optical fibre.
   - **(v)** Develop optical fibre communication systems.

Books Recommended

Text Books

Svelto, O	Principles of Lasers
Boyd, RW	Non-linear Optics
Shen, YR	The Principles of Nonlinear Optics
Ghatak, A and Thyagarajan, K	Introduction to Fibre Optics
Senior, JM	Optical Fibre Communications

Reference Books

Meyer-Arendt, JR	Introduction to Classical & Modern Optics
Buck, JA	Fundamentals of Optics and Photonics
Sarker, SK	Optical Fibres and Fibre Optic Communication Systems
Milonni, PW and Eberly, JH	Lasers

PH2202 THERMODYNAMICS (~28 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: ***50*** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***2*** *hours*

Prerequisite: PH2102, HSC level physics

Course Objective and Summary: This is a fundamental undergraduate course in physics designed to develop an in-depth knowledge of the laws of thermodynamics and to use this knowledge to explore various applications. Concepts of thermodynamic equilibrium, laws of thermodynamics, entropy, heat engines, thermodynamic potentials, phase transitions and various radiation laws are taught in this course. The elegance of thermodynamics is only surpassed by its importance as a core concept of physics, which is reflected throughout the course.

1. **Thermodynamic Fundamentals and First Law:** Thermodynamic Systems; Reservoirs, Thermodynamic Equilibrium and State of a System; Thermodynamic Processes and Cycles; Isothermal; Adiabatic; Quasi-Static; Reversible and Irreversible Processes; Internal Energy; Statement of First Law of Thermodynamics.

   Intended learning outcomes: Enable the students to:
   - **(i)** Explain the laws of thermodynamics and its place in Physics.
   - **(ii)** Gain the ability to use thermodynamic terminology appropriately.
   - **(iii)** Understand the concept of the systems, state variables and thermodynamic equilibrium.
   - **(iv)** Distinguish between various thermodynamic processes and calculate the work done in specific processes.
   - **(v)** Apply the concept of the first law of energy conversion.

2. **Second Law of Thermodynamics and Entropy:** Carnot's Cycle and Carnot's Theorem; Heat Engine and Refrigerators; Absolute Thermodynamic Temperature; Concept of Entropy, Entropy and Disorder; Principle of Increase of Entropy; Change of Entropy in Reversible and Irreversible Processes; Entropy Temperature Diagram; Theorem of Clausius; Clausius and Kelvin-Planck Statement of Second Law.

   Intended learning outcomes: Enable the students to:
   - **(i)** Explain the working mechanism of Carnot cycles.
   - **(ii)** Use the concept of entropy and the second law to solve thermodynamic problems.
   - **(iii)** Calculate the efficiency of various engines and explain why the efficiency cannot be 100%.

3. **General Thermodynamic Relations and Application to Simple Systems:** Thermodynamic Potential Functions; The Maxwell's Relations; Joule-Thomson Effect; Clausius-Clapeyron Equation; Chemical Potential; Gibbs Phase Rule; Heat Theorem and Third Law of Thermodynamics.

   Intended learning outcomes: Enable the students to:
   - **(i)** Use Maxwell's relations in various processes.
   - **(ii)** Explain the process of the liquefaction of gases and calculate the Joule-Thomson coefficient.
   - **(iii)** Explain basic features of phase transformations and calculate the temperature change with respect to pressure using the Clausius-Clapeyron equation.

Books Recommended

Text Books

Zemansky, MW	Heat and Thermodynamics
Sears, FW and Salinger, GL	Thermodynamics: Kinetic Theory and Statistical Mechanics
Finn, CBP	Thermal Physics
Hossain, T	Text Book on Heat
Saha, MN and Srivastava, BK	A Treatise on Heat

Reference Books

Roberts, JK and Miller, AR	Heat and Thermodynamics
Miah, W	Fundamentals of Thermodynamics
Reif, F	Fundamentals of Thermal Physics
Hoare, FE	Textbook of Thermodynamics
Schroeder, DV	Introduction to Thermal Physics
Brijlal and Subrahmanyam, N	Heat and Thermodynamics

PH2203 CLASSICAL MECHANICS-II (~ 28 *contact hours)*

Course Type: Core *Credit Point: 2*

Full Marks: ***50*** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***2*** *hours*

Prerequisites: PH2103

Course Objectives and Summary: Classical mechanics-II introduces Hamiltonian formulation, principle of least action, canonical transformations etc. Poisson bracket formulation, Hamilton-Jacobi theory and action angle are introduced for different specific problems and representations. Euler's theorem for the motion of rigid bodies is considered.

1. **Rigid Bodies:** Independent Coordinates of a Rigid Body; Orthogonal Transformations; Formal Properties of Transformation Matrix; Euler's Angles; Infinitesimal Rotations; Rate of Change of a Vector; The Coriolis Effect; The Euler Equations of Motion; Torque Free Motion of a Rigid Body; The Heavy Symmetrical Top with One Point Fixed; Stability of Rotation Motion.

   Intended learning outcomes: Enable the students to:
   - **(i)** Evaluate independent coordinates of a rigid body.
   - **(ii)** Find direction cosines and the Euler's angles.
   - **(iii)** Evaluate the properties of infinitesimal rotations.
   - **(iv)** Explain Coriolis force and its uses in meteorology, oceanography and other basic problems.

2. **Hamiltonian Formulation:** Legendre Transformations and the Hamilton's equations of motion; Phase Space and Motion of the System; Hamilton's Canonical Equations; Hamilton's Equations from Hamilton's Principle; Principle of Least Action.

   Intended learning outcomes: Enable the students to:
   - **(i)** Explain the Hamilton's principle and principle of stationary action.
   - **(ii)** Explain cyclic coordinates and symmetry.

3. **Canonical Transformations:** Canonical Transformation Equations; Poisson and Lagrange Brackets and their Properties; Invariance of Poisson Brackets with Respect to Canonical Transformations; Hamilton's Equations of Motion in Poisson Bracket Form; Jacobi's Identity; Relation between Poisson Bracket and Lagrange Bracket.

   Intended learning outcomes: Enable the students to:
   - **(i)** Explain the Hamilton's principle and principle of stationary action.
   - **(ii)** Explain cyclic coordinates and symmetry.
   - **(iii)** Derive the canonical transformation equations and use it in harmonic oscillator,
   - **(iv)** Find the Poisson and Lagrange brackets and evaluate their properties.

4. **Hamilton-Jacobi Theory:** Hamilton-Jacobi Equations for Hamilton's Principal and Characteristic Functions; Separation of Variables in Hamilton-Jacobi Equation; Action-Angle Variables; Applications.

   Intended learning outcomes: Enable the students to:
   - **(i)** Derive Hamilton-Jacobi equation and use it in harmonic oscillator problem.
   - **(ii)** Use action-angle variables in one degree of freedom, completely separate systems, Kepler problems.

Books Recommended

Text Books

Goldstein, G	Classical Mechanics
Hamill, P	A Student's Guide to Lagrangians and Hamiltonians
Taylor, JR	Classical Mechanics
Greiner, W	Classical Mechanics
Morin, D	Introduction to Classical Mechanics

Reference Books

Constant, FW	Theoretical Physics
Rana, NC and Joag, PS	Classical Mechanics
Spiegel, MR	Theoretical Mechanics
Gupta, Sl et al	Classical Mechanics
Gupta, KC	Mechanics of Particle & Rigid Bodies
Leech, JW	Classical Mechanics
Louis, NH and Janet, DF	Analytical Mechanics
Harun-or Rashid, AM	Chirayata Balavidya *(in Bangla)*
Biswas, SN	Classical Mechanics
Gregory, RD	Classical Mechanics
Hand, LN and Finch, JD	Analytical Mechanics

PH2211 MATRICES AND TENSORS (~42 contact hours)

Course Type: GEd *Credit Point: 3*

Full Marks: **75** (*Written Examination 52.5, In-course Evaluation 15 and Attendance 7.5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* **3** *hours*

Prerequisites: Matrices, differentiation and integration, algebra of intermediate level

Course Objectives and Summary: This is a basic course in mathematical physics to describe mathematical methods useful for solving problems in physics. This course covers matrix methods and tensor algebra that are widely used to explain various physical phenomena.

1. **Introduction to Matrix:** Type of Matrices; Determinant of a square matrix; Matrix Equivalence; Adjoint and Inverse of a Matrix; Orthogonal and Unitary Matrices.

   Intended learning outcomes: the successful students to:
   (i) Describe types of matrices.
   (ii) Describe use of various matrices to solve problems in physics.

2. **Matrix Transformation:** Linear equations; Vector spaces; Linear transformations; Characteristics roots and vectors.

   Intended learning outcomes: Enable the successful students to:
   (i) Solve linear equations
   (ii) Transform linear equations

3. **Matrix Properties:** Bilinear, Quadratic and Hermitian form of a Matrix; Similarity and Diagonalization of Matrices.

   Intended learning outcomes: Enable the successful students to:
   (i) Describe properties of matrices.
   (ii) Construct angular momentum matrices and spin matrices.
   (iii) Have basic knowledge about operator.

4. **Introduction to Tensor:** Spaces of N dimensions; Coordinate transformations; Summation convention; Contravariant and covariant vectors and tensors; Mixed tensors; Symmetric and skew symmetric tensors; Fundamental operations with tensors; Kronecker delta.

   Intended learning outcomes: Enable the successful students to:
   (i) Explain covariant and contravariant tensors and its basic uses in relativistic mechanics.
   (ii) Explain the fundamental operations with tensors to solve problems.
   (iii) Explain the properties of Christoffel symbols and use it in physical problems.

5. **Element of Tensors:** Line element and matric tensors; Conjugate tensors; Associated tensors; Christoffel's symbol; Geodesics.

   Intended learning outcomes: Enable the successful students to:
   (i) Explain the basic use of matric tensor in relativity.
   (ii) Explain the properties of Christoffel symbols and use it in physical problems.

6. **Derivative of Tensors:** Covariant derivative; Tensor from gradient, divergence and curl; Intrinsic derivative; Relative tensors.

   Intended learning outcomes: Enable the successful students to:
   (i) Explain derivatives of tensors and its basic uses in relativistic mechanics.
   (ii) Explain the properties of relative tensor and use it in physical problems.

Books Recommended

Text Books

Spiegel, MR	Vector Analysis and an Introduction to Tensor Analysis
Farid, SM	Introduction to Vectors and Special Functions
Pipes, L and Harvill, LR	Applied Mathematics for Engineers and Physicists
Ayres, F	Theory and Problems of Matrices

Reference Books

Sokolnikoff, IS and Redheffer, RM	Mathematics for Physics and Modern Physics
Margenau, H and Murphy, GM	Mathematics of Physics and Chemistry
Wong, CW	Introduction to Mathematical Physics
Joshi, AW	Matrices and Tensors in Physics
Ali, MI	Matrices and Linear Transformations

PH2212 SPECIAL FUNCTIONS AND COMPLEX VARIABLES (~42 contact hours)

Course Type: GEd *Credit Point: 3*

Full Marks: **75** (*Written Examination 52.5, In-course Evaluation 15 and Attendance 7.5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***3*** *hours*

Prerequisites: Factorial function, exponential and Gaussian functions, differentiation and integration, complex algebra of intermediate level

Course Objectives and Summary: This is a basic course in mathematical physics to describe mathematical methods and functions useful for solving problems in physics. This course also covers complex functions that are widely used to explain various physical phenomena.

1. **Functions:** Gamma functions, Beta functions, Bessel's functions, Legendre functions and their uses.

   Intended learning outcomes: Enable the successful students to:

   (i) Solve the problems using gamma and beta functions.
   (ii) Solve the problems using Bessel's function.

2. **Special Functions and Polynomials:** Legendre and Associated Legendre polynomial, Hermite Polynomials, Laguerre Polynomials.

   Intended learning outcomes: Enable the successful students to:

   (i) Solve the problems using Legendre polynomials and Hermite polynomials.
   (ii) Solve the problems using Laguerre polynomials .

3. **Applications of Special Functions:** Dirac-Delta functions; Fourier transforms and its applications; Fourier series and analysis of various wave forms; Laplace transformations and its applications; Laplace transform in a conducting cylinder within uniform field; Laplace transform in the potential about a spherical surface.

   Intended learning outcomes: Enable the successful students to:

   (i) Solve the problems of differential equation, quantum mechanics, wave analysis etc. using Fourier and Laplace transformations.
   (ii) Learn conversion of time domain signal into frequency domain.

4. **Complex Differentiation:** Derivatives and its Geometric interpretation; Analytic function; Cauchy-Riemann equations; Higher order derivatives; Complex differential operators.

   Intended learning outcomes: Enable the successful students to:

   (i) Calculate the modulus of a complex number.
   (ii) Plot real and imaginary number to show the effect of them.
   (iii) Explain the fundamental complex differential operators to solve problems.

5. **Complex Integration:** Complex line integrals; Cauchy's theorem and its consequences; Indefinite integrals; Integrals of special functions.

   Intended learning outcomes: Enable the successful students to:

   (i) Apply the Cauchy's theorem in physical problems.
   (ii) Explain the fundamental complex integral operators to solve problems.

6. **Cauchy's Integral Formulae:** Cauchy's Integral formula and its extension; Argument theorem; Poisson's integral formula.

   Intended learning outcomes: Enable the successful students to:

   (i) Explain integral formulae and use them in practical purpose.
   (ii) Apply this knowledge to analyze ac circuits and other physical problems.

7. **Residue Theorem:** Residues, Calculations of Residues, Residues at pole and infinity; Residue theorem and its consequences; Some definite integrals and consequences.

   Intended learning outcomes: Enable the successful students to:

   (i) Calculate the residues of a complex number at pole and infinity.
   (ii) Explain the residue theorems to solve problems.

Books Recommended

Text Books

Farid, SM	Introduction to Vectors and Special Functions
Pipes, L and Harvill, LR	Applied Mathematics for Engineers and

	Physicists
Spiegel, MR	Complex variables

Reference Books

Sokolnikoff, IS and Redheffer, RM	Mathematics for Physics and Modern Physics
Margenau, H and Murphy, GM	Mathematics of Physics and Chemistry
Wong, CW	Introduction to Mathematical Physics

PH2213 COMPUTATIONAL PHYSICS (~42 *contact hours)*

Course Type: GEd *Credit Point: 3*

Full Marks: **75** (*Written Examination 52.5, In-course Evaluation 15 and Attendance 7.5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* **3** *hours*

Using
(a) a programming language (Fortran and/or Python)
and selectively with
(b) Mathematica/Matlab

1. **Roots of Equations:** Bisection Method, Iterative Method, False-Position Method, Newton-Raphson Method.

   Intended learning outcomes: Enable the successful students to:

   (i) Choose a suitable method to solve an equation.
   (ii) Write a program to implement the method.
   (iii) Find solutions of equations using the method on a computer.

2. **Interpolation:** Lagrange Interpolation; Newton-Cotes interpolation; Gaussian Quadrature.

   Intended learning outcomes: Enable the successful students to:

   (i) Choose a suitable method to interpolate data.
   (ii) Write a program to implement the method.
   (iii) Obtain the interpolating curve or equation on a computer

3. **Numerical Integration:** Trapezoidal Method; Simpson's Method; Romberg Method.

   Intended learning outcomes: Enable the successful students to:

   (i) Choose a suitable method for a finite integration
   (ii) Write a program to implement the method
   (iii) Calculate the integrals on a computer

4. **Matrices**

   a. **Solution of system of equations / Inversion:** Matrix Inversion; Gauss Elimination Methods; Gauss-Jordon Method; Triangularization Method; Iterative Methods: Jacobi Method, Gauss-Seidel Method.

b. **Eigenvalue problem:** Eigenvalue Equation; Power Method; Jacobi Method; Givens Method; Householder Method.

Intended learning outcomes: Enable the successful students to:

(i) Choose a suitable method to solve an system of linear equations or an eigenvalue problem
(ii) Write a program to implement the method
(iii) Find solutions of the equations or eigenvalues on a computer

5. **Differential Equations:** Euler's Method; Runge-Kutta Methods; Shooting Method; Predictor-Corrector Methods: Adams-Moulton; Milne-Simpson.

Intended learning outcomes: Enable the successful students to:

(i) Choose a suitable method to solve a differential equation
(ii) Write a program to implement the method
(iii) Find solutions of differential equations on a computer

6. **Monte Carlo Methods:** Random number generators; Monte-Carlo integration; Random Walk; Metropolis algorithm.

Intended learning outcomes: Enable the successful students to:

(i) Use Monte Carlo methods to solve suitable problems
(ii) Write a program to implement the method

7. **Fourier Methods:** Fast Fourier Transform; Applications of Fourier Transform.

Intended learning outcomes: Enable the successful students to:

(i) Use Fourier transforms in suitable problems
(ii) Write a program, if necessary, to implement the method

8. **Advanced Topics:** Parallel Computing, Machine Learning.

Intended learning outcomes: Enable the successful students to:

(i) Assess whether a problem can be solved faster using parallel computing
(ii) Write basic parallel programs
(iii) Apply the basics of machine learning to solve simple problems

Books Recommended

Text Books

Landau, RH, Paez, MJ and Bordeianu, CC	Computational Physics: Problem Solving with Computers

Reference Books

Anagnostopoulos, KN	Computational Physics
Thijssen, JM	Computational Physics
Pang, T	An Introduction to Computational Physics

PH2221 COMPUTATION AND PROGRAMMING PRACTICAL(~56 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: **50** (*Continuous Assessment 15 marks, Attendance 5, Practical Exam 30 marks*)

(*1 day for Experiments*) *Examination duration:* **6** *hours*

Prerequisites: PH2113, HSC ICT

List of Experiments

1. Practicing of Programming (FORTRAN/MATLAB/C++).

Intended learning outcomes: Successful students should be able to:

(i) Compile and run computer programme.

2. For given experiments compose the theories and draw the data tables using MS-Office Word.

Intended learning outcomes: Successful students should be able to:

(i) Write with MS-Word.
(ii) Write equation.
(iii) Draw table.

3. For given experiments analyze data and draw graphs using MS-Excel.

Intended learning outcomes: Successful students should be able to:

(i) Analyses data (performing calculation and drawing graph) with MS-Excel.

4. For given experiments prepare presentation MS-power Point.

Intended learning outcomes: Successful students should be able to:

(i) Present a report with MS-Power Point.

Books Recommended

Lambert, J Step by Step Microsoft Word 2016
Schildt, H Turbo C/C++
Rajaraman, V Computer Programming in Fortran 90 and 95
Chapman, SJ Introduction to Fortran 90/95

PH2222 OPTICS PRACTICAL (Contact hours: ~56)

Course Type: Core *Credit Point: 2*

Full Marks: **50** (*Continuous Assessment 15 marks, Attendance 5, Practical Exam 30 marks*)

(*1 day for Experiments*) *Examination duration:* **6** *hours*

Prerequisites: PH2101

List of Experiments

1. Determination of Refractive Indices of Thick and Thin Prisms

Intended learning outcomes: Successful students should be able to:
- **(i)** Describe the characteristics of thin and thick prisms.
- **(ii)** Show ray trace through them.
- **(iii)** Define refractive index and relate it to the velocity of light.

2. Determination of Wavelength of Light by Diffraction through a Single Slit

Intended learning outcomes: Successful students should be able to:
- **(i)** Show the diffraction pattern.
- **(ii)** Measure the width of the principal maximum.
- **(iii)** Measure the width of the slit.

3. Determination of the wavelength of monochromatic light by Newton's ring method.

Intended learning outcomes: Successful students should be able to:
- **(i)** Understand the concept of coherent source in laboratory.
- **(ii)** Understand the formation of constructive and destructive interferences.
- **(iii)** Explain the causes of producing the circular rings.

4. Calibration of a Spectrometer and Determination of Unknown Wavelength.

Intended learning outcomes: Successful students should be able to:
- **(i)** Name and describe the functions of the essential parts of a spectrometer.
- **(ii)** Adjust the spectrometer and source including focusing for parallel rays.
- **(iii)** Find out the position of minimum deviation.
- **(iv)** Show graphically the relation of wavelength and angle of minimum deviation.

5. Determination of Wavelength by Plane Diffraction Grating and hence Determination of Resolving Power of a Grating

Intended learning outcomes: Successful students should be able to:
- **(i)** Understand the mechanism of discharge tube.
- **(ii)** Establish a relationship between wavelength and grating element.
- **(iii)** Explain how a grating forms a spectrum.
- **(iv)** Define resolving power of an optical instrument.

6. Calibration of a Polarimeter and hence Determination of Specific Rotation of a Sugar Solution.

Intended learning outcomes: Successful students should be able to:
- **(i)** Understand the function of polarizer and analyser.
- **(ii)** Define polarization of light.
- **(iii)** Show graphically the relation between concentration and angular rotation.

Books Recommended

Chawdhury, SA and Basak, AK	Byaboharik Padarthvidya*(in Bangla)*
Ahmed, G and Uddin, MS	Practical Physics
Nelkon, M and Ogborn, JM	Advanced Level Practical Physics

Tyler, F	Laboratory Manual of Physics
Worsnop, BL and Flint, HT	Advanced Practical Physics
Din, K and Matin, MA	Advanced Practical Physics

3rd Year 1st Semester

PH3101 ELECTRODYNAMICS-I	(~28 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: ***50*** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***2*** *hours*

Prerequisites: PH1102, PH1202, PH1111

Course Objective and Summary: The course deals with Maxwell's equations, wave equations in different media and their solutions, boundary conditions of wave propagation at an interface and their applications. This is one of the foundation undergraduate courses designed to make the students well-versed in the physics associated with electromagnetic wave propagation.

1. **Maxwell's Field Equations:** Maxwell's Equations; Electromagnetic Energy-Poynting Vector; Wave Equations and their solutions.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Set up Maxwell's wave equation and solve it.
   - **(ii)** Derive expression for Poynting vector.
   - **(iii)** Understand and apply the concepts of scalar and vector potentials.

2. **Propagation of Electromagnetic Waves:** Plane Waves in Infinite Medium.
   - **a)** Waves in Non-Conducting Media; Waves in Conducting Media.
   - **b)** Waves in Plasma; Concepts of Plasma; Conductivity; Plasma Frequency; Wave Propagation at High and Low Frequencies.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Solve wave equation in non-conducting and conducting media.
   - **(ii)** Explain wave propagation in plasma medium quantitatively.
   - **(iii)** Explain waves in crystalline medium quantitatively.

3. **Reflection and Refraction of EM Waves:** Boundary Conditions; Reflection and Refraction at Boundaries of two Non-Conducting Media; Metallic Reflection; Total Internal Reflection.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Differentiate between kinematics and dynamic properties of light.
   - **(ii)** Relate angle of incidence, reflection and refraction.
   - **(iii)** Calculate phase change and propagation energy of electromagnetic waves.

Books Recommended

Text Books

Reitz, JR et al	Foundations of Electromagnetic Theory
Griffiths, DJ	Introduction to Electrodynamics

Reference Books

Islam, AKMA & Islam, S	Tarit Gativijnan (*in Bangla*)
Huq, MS et al	Concept of Electricity and Magnetism
Gupta, SL et al	Electrodynamics
Tralli, N	Classical Electromagnetic Theory
Panofsky, WKH and Philip, M	Classical Electricity
Jackson, JD	Electrodynamics
Duffin, WJ	Advanced Electricity and Magnetism
Lim, YK	Introduction to Classical Electrodynamics
Slate, JC and Frank, NH	Electromagnetism
Chen, FF	Introduction to Plasma Physics
Sen, SN	Plasma Physics
Wangsness, RK	Electromagnetic Fields
Heald, MA and Marion, JB	Classical Electromagnetic Radiation

PH3102 QUANTUM MECHANICS-I (~28 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: **50** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* **2** *hours*

Prerequisites: PH1101, PH1201, PH1114, PH1214, PH2103, PH2203

Course Objectives and Summary: This course explains the nature and behavior of matter and energy on the atomic and subatomic levels. The course will allow students to perform calculations on simple systems using the Schrödinger equation.

1. **Physical Basis of Quantum Mechanics:** Shortcomings of Classical Theory; Two-slit Experiment; Wave Aspects of Matter; Wave Function and its Interpretation; Wave Packets and Uncertainty Principle.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Identify and understand the kinds of experimental results which are incompatible with classical physics and which required the development of a quantum theory of matter and light.
   - **(ii)** Interpret the wave function and apply operators to it to obtain information about physical systems.
   - **(iii)** Understand the role of uncertainty principle, and use the commutation relations of operators to determine whether or not two physical properties can be simultaneously measured.

2. **Formalism of Quantum Mechanics:**

   a) Operators, Measurements and Observable; Commutation of Observations; Operators in Dirac Notation, Linear Operators; Hermitian Operators; Eigenvalue Equations; Eigenvalues and Eigenfunctions; Eigenstates;

Orthonormality of Eigenstates; Parity, Degeneracy; Principle of Superposition; Probability Amplitudes; Probability Current Density; Overlap Integrals; Completeness; Change of Basis;

b) Wave Function in Position and Momentum Space, Normalization of Wavefunction.

c) Postulates of Quantum Mechanics; Correspondence Principle; Complementarity Principle.

Intended learning outcomes: Enables successful students to:

(i) Describe the formal structure of quantum mechanics.
(ii) Comprehend how measurements are interpreted in quantum mechanics.
(iii) Calculate the expectation value of various physical quantities and how the measurement process works in quantum mechanics.
(iv) Identify and relate the Eigen-value problems for energy, momentum and angular momentum.

3. **Schrödinger Wave Equation**: Characteristics of Schrödinger Equation, The Time-dependent Schrödinger Equation; Conservation of Probability; Imaginary potential; The Ehrenfest's Theorem; The time-independent Schrödinger Equation; Stationary States; The free particle, Energy Quantization; The Schrödinger Equation in Momentum representation. Entanglement and EPR paradox.

Intended learning outcomes: Enables successful students to:

(i) Analyze the behavior of quantum systems in time evolution using the time-dependent Schrödinger equation.
(ii) Apply Ehrenfest's Theorem to interpret the behavior of quantum systems in relation to classical mechanics.
(iii) Differentiate between the time-dependent and time-independent Schrödinger equations.
(iv) Solve the time-independent equation for specific potential energy functions.
(v) Demonstrate the advantages and applications of using momentum representation in certain quantum mechanical problems.
(vi) Explain the EPR paradox and its implications for the understanding of quantum mechanics.

Books Recommended

Text Books

Matthews, PT	Introduction to Quantum Mechanics
Griffiths, D	Introduction to Quantum Mechanics
Bransden, and Joachain, C	Quantum Mechanics
Jain, M C	Quantum Mechanics
Zettili, N	Quantum Mechanics: Concepts and Applications

Reference Books

Greiner, W	Quantum Mechanics

Powell, JL and Crasemann, B	Quantum Mechanics
Fong, P	Elementary Quantum Mechanics
Golder, SK	Quantum Balovidya (*in Bangla*)
Sherwin, CW	Introduction to Quantum Mechanics
Shankar, R	Principles of Quantum Mechanics
Agarwal, BK and Prakash, H	Quantum Mechanics
Gupta, Kumar and Sharma	Quantum Mechanics
Ziock, C	Basic Quantum Mechanics
Pauling, L and Wilson, EB	Quantum Mechanics

PH3103 RELATIVITY (~42 contact hours)

Course Type: Core *Credit Point: 3*

Full Marks: **75** (*Written Examination 52.5, In-course Evaluation 15 and Attendance 7.5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***3*** *hours*

Prerequisites: PH1101, PH2103, PH2203, PH2211

Course Objectives and Summary: This course describes the relativistic coordinate transformations, mass-energy equivalence, relativistic kinematics, relativistic dynamics with applications to relativistic phenomena in mechanics. The effects of gravity on space-time, gravitational waves, Schwarzschild spacetime and Hawking radiation are also described here.

1. **Background:** Space and Time in Newtonian Relativity; Inertial and Non-inertial Frames; Clock Synchronization, Galilean Transformations; Electromagnetism and Newtonian Relativity; Absolute Frame; Michelson and Morley Experiment; Implication of Negative Result.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Differentiate between inertial and non-inertial frames.
   - **(ii)** Demonstrate the Michelson and Morley Experiment and interpret its negative result.

2. **Special Relativity and Geometric Representation of Space-Time:** Postulates of Special Relativity; Relativity of Simultaneity; Lorentz Transformations and Its Consequences; Some Applications of Special Relativity; Minkowski Space; World Line; Space Time Interval; Geometrical Interpretation of Lorentz Transformation; Time Order and Space Separation of Events.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Explain the Postulates of Special Theory of Relativity.
   - **(ii)** Demonstrate Lorentz Transformations and explain time dilation, length contraction and twin paradox.
   - **(iii)** Demonstrate the Minkowski Space.
   - **(iv)** Explain the world line, space-time interval and causality.

3. **Relativistic Dynamics:** Mechanics and Relativity; Relativistic Momentum and Force; Equivalence of Mass and Energy; Four Vectors; Transformation Properties of Momentum; Energy, Mass and Force; Relativistic Lagrangian and Hamiltonian.

   Intended learning outcomes: Enables successful students to:
   (i) Explain the Equivalence of Mass and Energy.
   (ii) Use four vectors.
   (iii) Study relativistic Lagrangian and Hamiltonian.

4. **General Relativity and Physics in a Curved Space-Time:** Principle of Equivalence; Gravitational Red Shift; Mach's Principle; Principle of General Covariance; Correspondence Principle; Geodesic and Geodesic Deviation; Physics in Curved Spacetimes; Einsteinian and Newtonian Viewpoints of Gravity; Conserved Quantities.`

   Intended learning outcomes: Enables successful students to:
   (i) Demonstrate the principle of equivalence and covariance.
   (ii) Demonstrate gravitational red shift.
   (iii) Derive Geodesic equation.
   (iv) Explain Einsteinian and Newtonian gravity.

5. **Einstein Field Equations and Gravitational Radiation:** Purpose and Justification of the Field Equations; Weak Field Einstein's Equations; Newtonian Gravitational Field; Definition of Mass of a Relativistic Body; Detection of Gravitational Wave; Resonant Mass Detector; Laser Interferometers; Energy Flux of Gravitational Waves; Astrophysical Sources of Gravitational Waves.

   Intended learning outcomes: Enables successful students to:
   (i) Derive Einstein field equations.
   (ii) Explain gravitational wave.

6. **Schwarzschild Geometry and Black Holes:** Trajectories in the Schwarzschild spacetime; Black Holes in Newtonian Gravity; Conserved Quantities, Perihelion Shift; Binary Pulsars, Gravitational Deflection of Light, Gravitational Lensing, Formation and General Properties of Black Holes; Types of Black Holes; Hawking Radiation.

   Intended learning outcomes: Enables successful students to:
   (i) Explain precession of perihelion of planets.
   (ii) Explain the bending of light in gravitational field.
   (iii) Demonstrate Hawking radiation.

Books Recommended

Text Books

Resnick, R	Introduction to Special Relativity
Schutz, B	A First Course in General Relativity
Wald, RM	General Relativity
d'Inverno, R	Introducing Einstein's Relativity
Hartle, JB	Gravity: An Introduction to Einstein's

General Relativity

Reference Books

Einstein, A	Relativity- The Special and General Theory
Beiser, A	Concepts of Modern Physics
Prakash, S	Relativistic Mechanics
Bergmann, PG	Introduction to the Theory of Relativity
Griffiths, DJ	Introduction to Electrodynamics
Islam, JN	Introduction to Mathematical Cosmology
Fock, V	The Theory of Space, Time and Gravitation
Gamow, G	Gravitation
Rindler, W	Relativity: Special, General and Cosmological
Taylor, EF and Wheeler, JA	Spacetime Physics: Introduction to Special Relativity

PH3104 SOLID STATE PHYSICS-I (~42 contact hours)

Course Type: Core *Credit Point: 3*

Full Marks: **75** (*Written Examination 52.5, In-course Evaluation 15 and Attendance 7.5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***3*** *hours*

Prerequisites: Knowledge about coordinate system, vector addition and subtraction, dot and cross product, diffraction in real space, mass-spring concept, electronic configuration of atoms, Ohm’s law, direct and indirect band gap

Course Objectives and Summary: Difference between crystalline and non-crystalline materials along with their formation mechanism are explained. Electronic energy bands, lattice dynamics, mechanism of conduction and effects of various defects in semiconducting and conducting materials are also discussed.

1. **Crystal Systems:** Crystalline and Non-crystalline States; Unit Cell; Bravais Lattice; Symmetry Operations; Miller Indices; Simple Crystal Structures; Packing Factor; Inter-planar Spacing; Concept of Reciprocal Lattice; Brillouin Zone.

   Intended learning outcomes: Successful students should be able to:
   - **(i)** Locate atoms in a crystal using lattice translation vector.
   - **(ii)** Calculate distance between two planes.
   - **(iii)** Calculate the position of atoms in Cartesian coordinates
   - **(iv)** Draw primitive cell in a crystal.
   - **(v)** Demonstrate the conversion of Bragg diffraction law in real space into that in reciprocal space and vice versa.
   - **(vi)** Explain the limitation of crystal diffraction both in real and reciprocal space.

2. **Crystal Bindings:** Crystals of Inert Gas; Ionic Crystals; Binding Energy and Bulk Modulus; Covalent; Metal and Hydrogen Bonded Crystals.

   Intended learning outcomes: Successful students should be able to:

- **(i)** Understand the mechanism of various bondings.
- **(ii)** Calculate the bond energy associated with different bonds.
- **(iii)** Calculate bond strength that holds the atoms together to from the crystal structure.
- **(iv)** Explain the electronegativity of elements and formation of various compounds.

3. **Dynamics of Crystal Lattice:** Concept of Phonon; Elastic Vibration of a Continuous Medium; One-dimensional Monatomic and Diatomic Lattices; Theories of Lattice Specific Heat - Einstein Model and Debye Model.

Intended learning outcomes: Successful students should be able to:
- **(i)** Calculate vibrational frequencies of atoms in different types of crystals.
- **(ii)** Demonstrate the stability of crystal structure.

4. **Free Electron Theory of Metals:** Drude Model and Sommerfeld Model; Energy Levels and Density of Orbitals in One-dimension and Three-dimensions; Effect of Temperature on F-D Distribution; Electrical Conductivity and Ohm's Law; Thermal Conductivity of Metals; Electronic Heat Capacity; Wiedemann-Franz Law.

Intended learning outcomes: Successful students should be able to:
- **(i)** Calculate and plot free electron energy band in solids.
- **(ii)** Demonstrate inefficiency of the free electron model to explain band gap.
- **(iii)** Show the effect of electrons in conductivity in crystalline solids.
- **(iv)** Relate Fermi energy with free electron energy.

5. **Band Theory and Semiconductors:** Energy Bands in Crystals; Nearly Free Electron Model and Energy Gaps; Band Theory; Effective Mass of Electrons; Intrinsic and Extrinsic Semiconductors; Hall Effects for One and Two-carrier Systems.

Intended learning outcomes: Successful students should be able to:
- **(i)** Calculate the amount of band gap in crystals.
- **(ii)** Distinguish metal, semiconductor and insulator in terms of band gap.
- **(iii)** Predict the effect of crystal potential on energy band as well as the difference between free electron model and nearly free electron model.
- **(iv)** Calculate the effective mass of electron.
- **(v)** Calculate the amount of charge carriers and determine the type of semiconducting specimen.

6. **Imperfections in Crystals:** Classification of Defects; Point Defects; Dislocations: Screw and Edge Dislocations; Color Centers; Diffusion in Metals; Plane Defects; Crystal Grains and Grain Boundaries; Energy of Grain Boundaries.

Intended learning outcomes: Successful students should be able to:
- **(i)** Explain the formation and mechanism of defects produced in a crystal.
- **(ii)** Calculate the amounts of various defects as a function of temperance.
- **(iii)** Calculate the energy associated with grain boundary.
- **(iv)** Demonstrate and calculate the energy required to form various dislocations in crystals.

Books Recommended

Text Books

Kittel, C	Introduction to Solid State Physics
Omar, MA	Elementary Solid State Physics
Dekker, AJ	Solid State Physics
Puri and Babar	Solid State Physics

Reference Books

Mckelvey, JP	Solid State and Semiconductor Physics
Ashcroft and Mermin, A	Solid State Physics
Azaroff, LV and Brophy, JJ	Electronic Processes in Materials
Singhal, RL	Solid State Physics
Sze, SM	Physics of Semiconductor Devices
Wert, CA and Thomson, RM	Physics of Solids
Wahab, MA	Solid State Physics
Islam, MS	Kathin Abasthar Padartha Vijnan (*in Bangla*)

PH3105 CIRCUIT ANALYSIS AND ELECTRONICS FUNDAMENTALS

(~42 contact hours)

Course Type: Core *Credit Point: 3*

Full Marks: **75** (*Written Examination 52.5, In-course Evaluation 15 and Attendance 7.5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***3*** *hours*

Prerequisites: Students should have a solid understanding of electric charge, electric potential, electric field, and flow of charge through a medium. Additionally, a background in Calculus, Basic Electricity, and Magnetism is necessary for successful engagement in this course on Wave Filters, Transistor Biasing, and Thermal Stabilization

Course Objectives and Summary: This course focuses on Electronics Fundamentals, Circuit Analysis, Electronic Devices, Wave Filters, and Transistor Biasing. Students will delve into semiconducting materials, diode characteristics, circuit analysis techniques, and the application of various electronic devices including transistors and special diodes. The course covers wave filters, their design principles, and explores transistor biasing and thermal stabilization methods. Emphasis is placed on practical applications and theoretical understanding, preparing students for proficiency in electronic circuit analysis and design.

1. **Electronics Fundamentals:** Semiconducting Materials: p-type and n-type Materials; Semiconductor Diodes: Volt-Ampere Characteristics, Junction Capacitances.

   Intended learning outcomes: Successful students should be able to:

- **(i)** Differentiate between p-type and n-type materials.
- **(ii)** Explain the formation of depletion layer consisting of negative and positive ions.
- **(iii)** Know the mechanism of charge transfer through depletion region during the forward and reverse bias condition.
- **(iv)** Calculate the forward and reverse resistances

2. **Circuit Analysis:** Constant Voltage and Current Sources; their Conversions; Reduction of Complicated Networks-Equivalent Star and Delta Circuits, their Conversions; Superposition Theorem; Thevenin's Theorem; Norton's Theorem; Maximum Power Transfer Theorem.

   Intended learning outcomes: Successful students should be able to:

   - **(i)** Demonstrate the superposition theorem, Thevenin's Theorem, Maximum Power Transfer Theorem, and Norton's Theorem.
   - **(ii)** Reduce Complicated Networks to equivalent star and delta Circuits.

3. **Electronic Devices:** Diode Applications: Rectifier and Power Supplies; Special Diodes: Zener, Photo, LED and LCD; Transistors: Transistor DC and AC Characteristics; Equivalent Circuits in h-Parameters; Special Transistors: UJT, SCR, Phototransistor; FET: Construction and Characteristics of JFET and MOSFET.

   Intended learning outcomes: Successful students should be able to:

   - **(i)** Demonstrate the operation and applications of Zener, Photo, LED and LCD diodes.
   - **(ii)** Describe the operation of transistor and its characteristics.
   - **(iii)** Demonstrate the Construction and Characteristics of JFET and MOSFET.

4. **Wave Filters:** Symmetrical Networks; Characteristic Impedance, Propagation Constants; Filter Fundamentals: Pass and Stop Band; Constant-k Low Pass, High Pass, Band Pass, and Band Elimination Filters; Filter Design.

   Intended learning outcomes: Successful students should be able to:

   - **(i)** Design and construct filter.
   - **(ii)** Demonstrate the function of high pass, band pass, and band elimination filters.

5. **Transistor Biasing and Thermal Stabilization:** Factors Contributing to Thermal Instability; Stability Factors; Fixed Bias; Collector-Base Bias; Self-Bias; Bias Compensations.

   Intended learning outcomes: Successful students should be able to:

   - **(i)** Establish the predetermined voltages or currents at various points of an electronic circuit to establish proper operating conditions in electronic components.
   - **(ii)** Construct the biasing circuits and describe their merits and demerits.

Books Recommended

Text Books

Millman, J and Halkias, CC — Electronic Devices and Circuits

Boylestad, RL and Nashelsky, L	Electronic Devices and Circuit Theory
Ryder, J	Networks, Lines and Fields
Bhargav, NN et al	Basic Electronics and Linear Circuits
Theraja BL	Basic Electronics (Solid State)

Reference Books

Gupta, SL and Kumar, V	Hand Book of Electronics
Malvino, AP	Electronic Principles
Singh, A	Principles of Communications
Sharma, SP	Basic Radio and Television
Choudhury, GM	Electronics (*in Bangla*)
Mottershead, A	Electronic Devices and Circuits
Brophy, JJ	Basic Electronics for Scientists
Terman, R	Radio Electronics
Theraj, BL	Basic Electronics Solid State
MIT Staff	Transistors
Siskind, CS	Electrical Circuits
Arokh Singh	Electronic Communications
Theraja BL and Theraja AK	A Text Book of Electrical Technology

PH3106 ELECTRONICS (~ 28 *contact hours)*

Course Type: Core *Credit Point: 2*

Full Marks: **50** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* **2** *hours*

Prerequisites: Solid understanding of circuit analysis, electronic devices, and wave filters is required. Background in basic electricity, magnetism, semiconductor physics, and calculus is essential. Knowledge of feedback principles and oscillator basics is beneficial for successful engagement in this course

Course Objectives and Summary: This course encompasses Transistor Amplifiers, Feedback and Oscillator Circuits, and Radio Wave Propagation. Students will master transistor amplifier configurations, coupling techniques, and amplifier classes. Feedback principles and oscillator circuits, including phase-shift and crystal oscillators, will be explored. The course culminates in understanding radio wave propagation, modulation, demodulation, transmitter circuits, A.M. radio receivers, and antenna fundamentals. Emphasis is placed on theoretical comprehension and practical applications in the field of electronics..

1. **Transistor Amplifiers:** Transistor CE, CB and CC Amplifiers; Cascading and Coupling; Class A, Class B, Class C and Push-Pull Amplifiers.

   Intended learning outcomes: Successful students should be able to:

- **(i)** Demonstrate the use of a common emitter amplifier as a voltage amplifier.
- **(ii)** Demonstrate the use of a common base (grounded-base) amplifier as a current buffer or voltage amplifier.
- **(iii)** Demonstrate the use of a common collector amplifier as a voltage buffer.

2. **Feedback and Oscillator Circuits:** Feedback: Principles, Characteristics, Current and Voltage Feedback Amplifiers; Oscillator: Positive Feedback; Condition for Sustained Oscillation; Phase-Shift, Wein-Bridge, Hartley, Colpitt's and Crystal Oscillators.

Intended learning outcomes: Successful students should be able to:

- **(i)** Demonstrate the operation of feedback circuits.
- **(ii)** Explain positive and negative feedback.
- **(iii)** Describe the production of a periodic, oscillating electronic signal, often a sine wave or a square wave using an oscillator.
- **(iv)** Demonstrate the generation of sine waves of a large range of frequencies.
- **(v)** Describe the operation of a Colpitt's oscillator that uses a combination of inductors and capacitors to produce an oscillation at a certain frequency.

3. **Radio Wave Propagation:** Modulation; Demodulation; Transmitter Circuits; A.M. Radio Receiver, Wave Propagation through Ionosphere; Antenna: Fundamentals, Types of Antenna and Arrays.

Intended learning outcomes: Successful students should be able to:

- **(i)** Demonstrate the process of varying one or more properties of a periodic waveform, called the carrier signal.
- **(ii)** Demonstrate the operation of an AM radio receiver.
- **(iii)** Describe Wave Propagation through the Ionosphere.

Books Recommended

Text Books

Millman, J and Halkias, CC	Electronic Devices and Circuits
Boylestad, RL and Nashelsky, L	Electronic Devices and Circuit Theory
Ryder, J	Networks, Lines and Fields
Bhargav, NN et al	Basic Electronics and Linear Circuits
Theraja BL	Basic Electronics (Solid State)

Reference Books

Gupta, SL and Kumar, V	Hand Book of Electronics
Malvino, AP	Electronic Principles
Singh, A	Principles of Communications
Sharma, SP	Basic Radio and Television
Choudhury, GM	Electronics (*in Bangla*)
Mottershead, A	Electronic Devices and Circuits
Brophy, JJ	Basic Electronics for Scientists
Terman, R	Radio Electronics
Theraj, BL	Basic Electronics Solid State

MIT Staff	Transistors
Siskind, CS	Electrical Circuits
Arokh Singh	Electronic Communications
Theraja BL and Theraja AK	A Text Book of Electrical Technology

PH3121 MODERN PHYSICS PRACTICAL-I (~56 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: ***50*** (*Continuous Assessment 15 marks, Attendance 5, Practical Exam 30 marks*)

(*1 day for Experiments*) *Examination duration:* ***6*** *hours*

Prerequisites: PH1121

List of Experiments

1. Determination of the Plateau and Operating Voltage of a Geiger-Muller Counter.

   Intended learning outcomes: Successful students should be able to:
   - **(i)** Characterize any Geiger-Müller Counter in terms of its plateau length, plateau slope and operating voltage.

2. Calibration of an Electromagnet by an Exploring Coil.

   Intended learning outcomes: Successful students should be able to:
   - **(i)** Calibrate an electromagnet with the help of a ballistic galvanometer.
   - **(ii)** Understand the factors affecting the magnetic field intensity at a point within the poles.
   - **(iii)** Narrate how the law of electromagnetic induction and Lenz's law work in this experiment.

Books Recommended

Text Books

Price, WJ	Nuclear Radiation Detection
Beiser, A	Concepts of Modern Physics

PH3122 ELECTRONICS PRACTICAL-I (~56 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: ***50*** (*Continuous Assessment 15 marks, Attendance 5, Practical Exam 30 marks*)

(*1 day for Experiments*) *Examination duration:* ***6*** *hours*

Prerequisites: PH1121, PH1102, PH1202, PH1222, PH2122

List of Experiments

1. Construction and Study of a Low-pass Filter.

   Intended learning outcomes: Successful students should be able to:

(i) Design and construct a low-pass filter.
(ii) Calculate the filter parameters.

2. Construction and Study of a High-pass Filter.

Intended learning outcomes: Successful students should be able to:
(i) Design and construct a high-pass filter.
(ii) Calculate the filter parameters.

3. Construction and Study of the Frequency Response Curves of a Single-Stage AF Amplifier with and without Feedback.

Intended learning outcomes: Successful students should be able to:
(i) Design and construct a single stage AF amplifier with and without feedback.
(ii) Know the potential divider biasing method.
(iii) Know how to plot wide range of data on a semi-log graph paper and observe frequency responses of amplification circuits.
(iv) Calculate cut-off frequency and band-width of the designed amplifier.
(v) Effect of negative feedback on gain and bandwidth.

4. Characteristics of a FET and Determination of its Parameters.

Intended learning outcomes: Successful students should be able to:
(i) Study the characteristics of FET ($I_D \sim V_{DS}$ and $I_D \sim V_{GS}$ curves).
(ii) Calculate the FET parameters (amplification factor, drain resistance and mutual conductance).

5. Construction of Full-wave Bridge Rectifier using Semiconductor Diodes and Study the Effect of Filters.

Intended learning outcomes: Successful students should be able to:
(i) Understand the concept of rectification.
(ii) Construct a low voltage power-supply unit.

Books Recommended

Text Books

Chowdhury, SA and Basak, AK	ByaboharikPadarthavidya(*in Bangla*)
Tyler, F	Laboratory Manual of Physics
Worsnop, BL and Flint, HT	Advanced Practical Physics
Bar, Z and Malvino, AP	A Text Lab. Manual: Basic Electronics
Tout, E & Jansen, GJ	Practical Structure Determination

3rd Year 2nd Semester

PH3201 ELECTRODYNAMICS-II	(~28 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: ***50*** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***2*** *hours*

Prerequisites: PH3101

Course Objective and Summary: The course deals with waveguides, retarded potentials, Lienard-Wiechert potentials, radiation, and relativistic electrodynamics.

1. **Guided Waves:** Wave Guides; TE Waves in a Rectangular Wave Guide; The Coaxial Transmission Line.
   Intended learning outcomes: Enable the successful students to:
   (i) Derive field equations for plane waves propagating in a particular direction between the infinite conducting parallel planes.
   (ii) Grasp the idea of wave propagation through optical fibre.
2. **Potential and Fields:** Scalar and Vector Potentials; Gauge Transformations; Inhomogeneous Wave Equations; Retarded Potentials; Lienard-Wiechert Potentials; The field of a moving Point Charge.
   Intended learning outcomes: Enable the successful students to:
   (i) Know what Lienard-Wiechert potentials do.
   (ii) Calculate the electric field and magnetic field from the potentials.
   (iii) Know the implications of Lienard-Wiechert potentials.
   (iv) Know how the field varies due to accelerated point charge.
3. **Radiation:** Electric Dipole Radiation; Magnetic Dipole Radiation; Radiation from an Arbitrary Source; Power Radiated by a Point Charge; Radiation Reaction.
   Intended learning outcomes: Enable the successful students to:
   (i) Learn how electrons become bound in a material.
   (ii) Relate Compton scattering with the Thompson scattering.
   (iii) Explain how Thompson scattering takes place and calculate the cross section of this scattering.
   (iv) Know how the knowledge of Thompson scattering can be applied to cosmic microwave background, x-ray crystallography and inverse Compton scattering.
   (v) Explain the reason of blue hue of the daytime sky and reddening of the sun during sunset.
   (vi) Calculate the energy loss in optical fiber using Rayleigh scattering.
4. **Relativistic Electrodynamics:** Magnetism as a Relativistic Phenomenon; Transformation of E and B Field Tensors; Invariance of Maxwell's Field Equations.
   Intended learning outcomes: Enable the successful students to:
   (i) Describe magnetism as a relativistic phenomenon.
   (ii) Show the invariance of Maxwell's field equations.

Books Recommended

Text Books

Griffiths, DJ	Introduction to Electrodynamics
Resnick, R	Introduction to Special Relativity
Reitz, JR et al	Foundations of Electromagnetic Theory

Reference Books

Islam, AKMA & Islam, S	Tarit Gativijnan (*in Bangla*)
Huq, MS et al	Concept of Electricity and Magnetism
Gupta, SL et al	Electrodynamics
Tralli, N	Classical Electromagnetic Theory
Panofsky, WKH and Philip, M	Classical Electricity
Jackson, JD	Electrodynamics
Duffin, WJ	Advanced Electricity and Magnetism
Lim, YK	Introduction to Classical Electrodynamics
Slate, JC and Frank, NH	Electromagnetism
Chen, FF	Introduction to Plasma Physics
Sen, SN	Plasma Physics
Wangsness, RK	Electromagnetic Fields
Heald and Marrion	Classical Electromagnetic Radiation

PH3202 QUANTUM MECHANICS-II (*~ 28 contact hours)*

Course Type: Core *Credit Point: 2*

Full Marks: ***50*** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***2*** *hours*

Prerequisites: PH1101, PH1201, PH1114, PH1214, PH2103, PH2203, PH3102

Course Objectives and Summary: This course explains the nature and behavior of matter and energy on the atomic and subatomic levels. The course will allow students to perform calculations on simple systems using the Schrödinger equation. Applications, such as stationary states of the hydrogen atom, harmonic oscillator, etc. are discussed.

1. **Problems in One Dimension:** General formula, Particle in a Potential Box; Infinite square well, Finite Square well, Potential Step; Tunneling through a Potential Barrier; Rectangular Potential Well; Ladder operator, Linear Harmonic Oscillators.

   Intended learning outcomes: Enables successful students to:

   (i) Solve the Schrödinger equation to obtain wave functions and eigenvalues for some basic, physically important types of potential in one dimension.

   (ii) Calculate the energy eigenvalues of linear harmonic oscillator.

2. **Spherically Symmetric Systems**

a) Three-dimensional Schrödinger Equation for Spherically Symmetric Potentials; Spherical Harmonics; Three Dimensional Potential Wells-degenerate States.

b) Two-body Problems-Hydrogen Atom: Schrödinger Equation for Hydrogen Atom; Electron Probability Density; Spectrum of Hydrogen; Rigid Rotor.

Intended learning outcomes: Enables successful students to:

(i) Apply the technique of separation of variables to solve problems in three dimensions and understand the role of degeneracy in the occurrence of electron shell structure in atoms.

Books Recommended

Text Books

Matthews, PT	Introduction to Quantum Mechanics
Griffiths, D	Introduction to Quantum Mechanics
Bransden, and Joachain, C	Quantum Mechanics
Jain, M C	Quantum Mechanics

Reference Books

Greiner, W	Quantum Mechanics
Powell, JL and Crasemann, B	Quantum Mechanics
Fong, P	Elementary Quantum Mechanics
Golder, SK	Quantum Balovidya (*in Bangla*)
Sherwin, CW	Introduction to Quantum Mechanics
Shankar, R	Principles of Quantum Mechanics
Agarwal, BK and Prakash, H	Quantum Mechanics
Gupta, Kumar and Sharma	Quantum Mechanics
Ziock, C	Basic Quantum Mechanics
Pauling, L and Wilson, EB	Quantum Mechanics

PH3203 STATISTICAL MECHANICS-I (~28 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: **50** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* **2** *hours*

Prerequisites: PH1214, PH2202, PH2103, PH2203, PH3102

Course Objectives and Summary: The course gives an introduction to statistical mechanics with an emphasis on applications. It discusses how probability theory can be used to derive relations between the microscopic and macroscopic properties of matter. The course is designed to enable the students to comprehend the important concepts of phase space, energy distributions in phase space, different ensembles, Maxwell-Boltzmann distributions and their applications under variety of conditions.

1. **Classical Statistical Mechanics-Essential Concepts:** Statistical Mechanics; Phase Space and Phase Trajectory; Volume in Phase Space; Specification of States of a System; Density of States and its General Behaviour; Liouville's Theorem and its Consequence; Postulates of Classical Statistical Mechanics; Macrostates and Microstates; Thermodynamic Probability; Statistical Equilibrium; Stirling's Approximation.

   Intended learning outcomes: Enables successful students to:
   (i) Specify macroscopic systems in phase space.
   (ii) Derive the Liouville's equation and explain its consequences.
   (iii) Comprehend the postulates of statistical mechanics.
   (iv) Calculate thermodynamical probability for classical particles.

2. **Statistical Ensembles:** Classical Ensembles; Its Classification and Usage Entropy; Gibbs Paradox; Sackur-Tetrode Equation.

   Intended learning outcomes: Enables successful students to:
   (i) Classify different classical ensembles.
   (ii) Relate thermodynamical probability to entropy.
   (iii) Derive and apply Sackur-Tetrode Equation.

3. **Classical Statistical Distribution:** Maxwell Velocity Distribution; Boltzmann Energy Distribution Function; Maxwell-Boltzmann Statistics and its Applications; Partition Functions and Thermodynamical Potentials; Principle of Equipartition of Energy.

   Intended learning outcomes: Enables successful students to:
   (i) Derive and apply Boltzmann distribution function.
   (ii) Apply Maxwell-Boltzmann statistics to calculate velocities of the particles.
   (iii) Apply partition function to obtain different thermodynamical parameters.

Books Recommended

Text Books

Pathria, RK	Statistical Physics
Huang, K	Statistical Mechanics
Reif, B	Fund. of Statistical and Thermal Physics
Gupta, SL et al.	Elementary Statistical Mechanics
Brijlal, L et al.	Thermal and Statistical Physics
Kardar, M	Statistical Mechanics of Particles

Reference Books

Berkeley Physics Course, V	Statistical Physics
Kittel, C and Kroemer, H	Thermal Physics
Stowe,K	Introduction to Statistical Mechanics
Pointon, AJ	Introduction to Statistical Physics
Singh, K et al.	Elements of Statistical Mechanics
Allis, WP and Herlin, MA	Thermodynamics and Statistical Mechanics
Riedl, PC	Thermal Physics

Saha, MN and Srivastava, BN	Treatise on Heat
Beiser, A	Concept of Modern Physics
Constant, FW	Theoretical Physics 2
Sears FW and Salinger, GL	Thermodynamics, Kinetic Theory & Statistical Mechanics
Agarwal, BK and Eisner, M	Statistical Mechanics

PH3204 ATOMIC AND MOLECULAR PHYSICS (~42 contact hours)

Course Type: Core *Credit Point: 3*

Full Marks: **75** (*Written Examination 52.5, In-course Evaluation 15 and Attendance 7.5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* **3** *hours*

Prerequisites: PH1111, PH3102

Course Objectives and Summary: This course aims to study the physical properties of atoms and molecules focusing on the role of atoms as the building blocks of matter based on the atomic models. It mainly deals with the interactions between matters and light-matter on the scale of one or a few atoms and energy scales around several electron volts. Atomic and molecular theory includes classical, semi-classical and quantum treatments of emission, absorption, scattering of electromagnetic radiation (light) from excited atoms and molecules.

1. **Atomic Models:** Rutherford's Nuclear Atom; Atomic Spectra; Bohr Model and Structure of Atoms; Atomic Excitation; Franck-Hertz Experiment; Correspondence Principle; Correction for Nuclear Motion.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Explain Rutherford's nuclear atom.
   - **(ii)** Describe the Bohr model and calculate electron energy levels.
   - **(iii)** Describe the Franck-Hertz experiment to show the quantum nature of atoms.
   - **(iv)** Explain Correspondence Principle.

2. **Wave-Particle Duality:** Photoelectric Effect; Einstein's Photoelectric Equation and its Experimental Verification; de Broglie Waves; Experimental Verification of Particle Waves; Wave and Group Velocities.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Illustrate the wave-particle duality.
   - **(ii)** Explain the emission of electrons or other free carriers when light is impinged onto a material.
   - **(iii)** Calculate de Broglie wavelength.

3. **X-Rays:** Production and Properties of X-Rays; Continuous and Characteristic X-Rays; X-Ray Spectra; X-Ray Absorption; Moseley's Law; Compton Effect.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Demonstrate the production of X-rays.

- **(ii)** Differentiate between continuous and characteristic X-rays.
- **(iii)** Demonstrate the inelastic scattering of a photon by a charged particle, usually an electron in Compton effect.

4. Electron Spin and Complex Atoms: Spin Angular Momentum; Identical Particles; Exclusion Principle; Stern-Gerlach Experiment; Spin-Orbit Interaction-Fine Structure; Total Angular Momentum of Atoms; Atomic Spectra (Helium, Sodium and Mercury); Zeeman Effect, Stark Effect.

Intended learning outcomes: Enable the successful students to:

- **(i)** Explain the intrinsic angular momentum.
- **(ii)** Demonstrate the Pauli exclusion principle.
- **(iii)** Demonstrate the interaction of a particle's spin with its motion.
- **(iv)** Explain the splitting a spectral line into several components in the presence of a static magnetic field.
- **(v)** Explain the shifting and splitting of spectral lines of atoms and molecules due to presence of an external electric field.
- **(vi)** Describe the splitting of the spectral lines of atoms due to electron spin and relativistic corrections to the non-relativistic Schrödinger equation.

5. Molecular Spectra: Molecular Spectra of Diatomic Molecules; Rotational Spectra; Vibrational-Rotational Spectra; Molecular Quantum States; UV- Spectra; Raman Spectra.

Intended learning outcomes: Enable the successful students to:

- **(i)** Characterize materials using X-ray spectroscopy.
- **(ii)** Measure of the energies of transitions between quantized rotational states of molecules in the gas phase.
- **(iii)** Demonstrate the vibrational, rotational and other low-frequency modes in a system.

Books Recommended

Text Books

Beiser, A	Concepts of Modern Physics
Krane, K	Modern Physics
Rajam, JB	Atomic Physics

Reference Books

Bransden, BH and Joachain, CJ	Physics of Atoms and Molecules
Enge, HA et al	Introduction to Atomic Physics
Husain, A and Islam, GS	Paramanabik Vijnan (*in Bangla*)
Islam, GS	Paramanbik Ebong Nucleo Padarthavijnan, Vol.1
Semat, H & Albright Jr	Introd. to Atomic and Nuclear Physics
Brehm and Mullen	Introduction to the Structure of Matter
Richtmeyer,FK	Introduction to Modern Physics
Acosta, V and Cowan, GL	Essentials of Modern Physics
Kiruthiga, S and Murughesan, R	Modern Physics

PH3205 NUCLEAR PHYSICS-I (~42 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: **75** (*Written Examination 52.5, In-course Evaluation 15 and Attendance 7.5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* **3** *hours*

Prerequisites: PH1211, PH3102

Course Objective and Summary: This course deals with nuclear properties, nuclear force and nuclear reactions. It covers the area of study on radioactive nuclides and their decay modes along with the detection of nuclear particles. The mechanism of interactions of charged particles and radiations with matter, and different methods of acceleration of charged particles are also included in this course.

1. **The Nucleus:** Constituent of Nuclei; Nuclear Mass; Charge and Density; Nuclear Sizes and Shapes; Mass Defect; Binding Energy; Nucleon Separation Energy; Nuclear Force; Meson Theory of Nuclear Forces;

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Understand nucleon.
   - **(ii)** Calculate the nuclear as well as atomic mass.
   - **(iii)** Calculate the nuclear mass defect and binding energy.
   - **(iv)** Learn nature and properties of nuclear force.

2. **Radioactivity:** Radioactive Decay Laws; Half-Life and Mean-Life; Secular and Transient Equilibrium; Artificial Radioactivity; Uses of Radioisotopes; Units of Radioactivity.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Learn about natural and artificial radioactive material.
   - **(ii)** Calculate half-life and mean life of a radioactive material.
   - **(iii)** Realize the use of radioisotopes in nuclear medicine, radiation therapy treatment, agriculture and industrial purposes.
   - **(iv)** Understand the physical meaning of unit of radioactivity.

3. **Alpha, Beta, and Gamma Emissions:** Theory of Alpha-Decay; Fine structure of Alpha decay, Beta Decay and its Energy Measurement; Conservation of Energy and Momentum in Beta Decay; Neutrino Hypothesis; Orbital Electron Capture; Positron Emission; Mass Conditions for Beta Decay; Gamma Decay; Mean Lives for Gamma Emission; Internal Conversion.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Get idea about conversion of parent nucleus into daughter nucleus and draw the transitions for different excited states.
   - **(ii)** Calculate and draw decay energy for different emissions.
   - **(iii)** Learn about neutrino and the conditions for different types of beta decay.
   - **(iv)** Understand about gamma emission and internal conversion of an excited nucleus.

4. **Nuclear Reactions:** Different Types of Reactions; Conservation of Physical Quantities; Energetics of Nuclear Reactions; Cross-Section; Compound Nucleus Hypothesis; Production and Properties of Neutrons, Interaction of charged particles with matter.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Learn about different types of nuclear reaction mechanism and conservation condition for the same.
   - **(ii)** Calculation of energy and cross section of a nuclear reaction.

5. **Nuclear Detectors:** Ionization Chambers; Proportional Counter; Geiger-Muller Counters, Scintillation detector and semiconductor detectors.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Development of idea about the detection mechanism for different types of radiation with various detector systems.
   - **(ii)** Calculation of the intensity and energy of a radiation.

6. **Particle Accelerators:** Linear Accelerator; Betatron; Cyclotron; Introduction to LHC.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Learn about the charge particle acceleration mechanism and the calculation of the energy of the charge particle.

7. **Nuclear Fission and Fusion:** Fission Process; Energy Release in Fission; Chain Reaction; Nuclear Fusion; Thermonuclear Reaction in Stars.

   Intended learning outcomes: Enable the successful students to:
   - **(i)** Learn about fission and fusion reaction mechanism and their practical applications.
   - **(ii)** Calculation of fission and fusion energy.

Books Recommended

Text Books

Beiser, A	Concepts of Modern Physics
Islam, AKMA & Islam, MA	Nucleo Padarthavijnan *(in Bangla)*
Islam, GS	Paramanbik ebong Nucleo Padarthavijan, Vol. 2
Kaplan, I	Nuclear Physics

Reference Books

Burcham,WE	Nuclear Physics
Cohen, BL	Concepts of Nuclear Physics
Enge, HA	Introduction to Nuclear Physics
Krane, K	Introductory Nuclear Physics
Wong, SSM	Introduction to Nuclear Physics
Evans, AD	Atomic Nucleus
Meyerhof, WE	Elementary Nuclear Physics
Smith, CMH	Text Book of Nuclear Physics
Heyde, K	Basic Ideas and Concepts in Nuclear Physics

PH3211 RENEWABLE ENERGY AND METEOROLOGY (~42 contact hours)

Course Type: GEd *Credit Point: 3*

Full Marks: **75** (*Written Examination 52.5, In-course Evaluation 15 and Attendance 7.5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***3*** *hours*

Prerequisite: PH3104

Course Objectives and Summary: The objective of this course is to describe the importance of renewable sources of energy and meteorology. It describes how solar energy is collected and stored. This course also explains the working principle of photovoltaic system and its application to meet the energy crisis. Another objective of this course is to study our environmental situation and weather conditions. It describes the weather elements and monitoring systems.

1. **Introduction:** World Energy requirement and Reserve; Energy crisis; Production of Energy in the Sun; Solar Constant; Solar Geometry; Azimuth; Declination; Day Length; Solar Time; Solar Radiation on the Tilted Surface; Measurement of Solar Radiation.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Describe the process of energy production in the sun.
   - **(ii)** Calculate solar intensity, declination, hour angle, and day length.
   - **(iii)** Calculate solar time.
   - **(iv)** Explain and use various solar radiation measurement techniques.

2. **Solar Collectors:** Flat Plate Collectors; General Description of Flat Plate Collector; Heat Transfer Properties of Flat Plate Collector; Energy Balance; Temperature Distribution; Collector Overall Heat Transfer Coefficient; Collector Efficiency Factor; Heat Removal Factor and Flow Factor.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Collect and transfer solar energy for practical purposes.
   - **(ii)** Derive and solve energy balance equation for solar collectors.
   - **(iii)** Calculate overall heat transfer coefficient of a solar collector.
   - **(iv)** Estimate collector efficiency, heat removal factor, and flow factor.
   - **(v)** Prepare selective surfaces to minimize thermal loss.
   - **(vi)** Prepare anti-reflection coating to reduce optical loss.

3. **Energy Storage:** Types of Energy Storage; Sensible Heat Storage; Latent Heat Storage; Thermochemical Storage.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Describe different solar energy storage arrangements.
   - **(ii)** Design different solar energy storage systems.

4. **Photovoltaics:** Interaction of Light with Semiconductor; Absorption and Recombination Processes; Photovoltaic Principles; Semiconductor Junction;

Materials for Solar cell; Fabrication; Assembly of Homojunction and Heterojunction solar cell, Solar cell Characteristics, Power Output, Efficiency and Efficiency Limit.

Intended learning outcomes: Enables successful students to:
- **(i)** Understand optical absorption and recombination processes in semiconductors.
- **(ii)** Explain working principle of photovoltaic cells.
- **(iii)** Choose suitable materials for solar cell.
- **(iv)** Calculate and explain solar cell characteristics.
- **(v)** Estimate the power factor and efficiency of solar cells.

5. **Photovoltaic System and Modules:** Basic Photovoltaic System for Power Generation; Solar Modules; Module Circuit Design; Application of Photovoltaic System; New Developments of Solar Panel.

Intended learning outcomes: Enables successful students to:
- **(i)** Design photovoltaic modules for power generation.
- **(ii)** Design solar panels.

6. **Other Sources of Non-conventional Energy**
   a) Wind Power: Suitability of Wind Power; Factors of Wind Speed; Height above Ground and Terrain Characteristics; Betz' Law; Basic Wind Power System; Advantages and Disadvantages of Wind Power.
   b) Biomass and Biogas; Introduction to Tidal Power and Fuel Cells.

Intended learning outcomes: Enables successful students to:
- **(i)** Design a basic wind power system.
- **(ii)** Apply Betz' law for wind power utilization.
- **(iii)** Design biogas plant.
- **(iv)** Describe the prospects of tidal power and fuel cells to meet energy crisis.

7. **Meteorology Fundamentals and Applications:** Introduction; Classification of Meteorology; Dynamic Meteorology: Solar Heating and Atmospheric Motion, Fluid Dynamics in Meteorology; Physical Meteorology: Physical Characteristics of Earth and Atmosphere, Cloud Physics; Applied Meteorology: Hydrometeorology, Aviation Meteorology; Radar and Satellite Meteorology; Agricultural Meteorology.

Intended learning outcomes: Enables successful students to:
- **(i)** Explain atmospheric conditions, characteristics and factors affecting the atmospheric situations.
- **(ii)** Recognize the fundamental ideas of turbulence and fluid dynamics.
- **(iii)** Explain the physical processes underlying clouds and precipitation.
- **(iv)** Understand the fundamentals of hydrometeorology and how it applies to water resources.
- **(v)** Explain the processes important for aviation Meteorology.
- **(vi)** Provide early warning and advice to agriculture services for crop management.

8. **Measuring and Forecasting Weather:** Weather Elements Measuring Instruments; Weather Models; Weather Forecasting.

Intended learning outcomes: Enables successful students to:
- **(i)** Acquire knowledge of various weather element measuring devices.
- **(ii)** Become familiar with various weather models.
- **(iii)** Predict weather using several models.

Books Recommended

Text Books

Rai, GD	Solar Energy Utilization
Rapp, D	Solar Energy
Anderson, EE	Fundamental of Solar Energy Conversion
Lutgens, F, Tarbuck, E & Herman, R	The Atmosphere: An Introduction to Meteorology
Spiridonov, V and Curie, M	Fundamentals of Meteorology

Reference Books

Rai, GD	Non-conventional Source of Energy
Duffiee, JA	Solar Engineering of Thermal Process
Green, MA	Solar Cell
Magal, BS	Solar Power Engineering
Neville, RC	Solar Energy
Fisk, MJ and Anderson, HCW	Introduction to Solar Technology
Khan, BH	Non-conventional Energy Resources
Schmitter, A	Introduction to Cloud Science
Brune, W	Fundamentals of Atmospheric Science
Ahrens, CD and Henson, R	Essentials of Meteorology

PH3221 MODERN PHYSICS PRACTICAL-II (~56 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: ***50*** (*Continuous Assessment 15 marks, Attendance 5, Practical Exam 30 marks*)

(*1 day for Experiments*) *Examination duration:* ***6*** *hours*

Prerequisites: PH3121

List of Experiments

1. Study of Photoelectric Effect

Intended learning outcomes: Successful students should be able to:
- **(i)** Explain the phenomenon of photoelectric effect in detail.
- **(ii)** Calculate the stopping potential for a given frequency.
- **(iii)** Understand the effect of intensity of the incident radiation on the photocurrent.

2. Determination of e/m of an Electron

Intended learning outcomes: Successful students should be able to:
- **(i)** Explain the trajectory of electrons under applied magnetic field.
- **(ii)** Calculate the specific charge of an electron.

3. Study of Absorption of Gamma Rays.

Intended learning outcomes: Successful students should be able to:

(i) Investigate the absorption of gamma rays in matter, calculate the half-value thickness and absorption coefficients.

Books Recommended

Text Books

Price, WJ	Nuclear Radiation Detection
Beiser, A	Concepts of Modern Physics

PH3222 ELECTRONICS PRACTICAL-II (~56 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: ***50*** (*Continuous Assessment 15 marks, Attendance 5, Practical Exam 30 marks*)

(*1 day for Experiments*) *Examination duration:* ***6*** *hours*

Prerequisites: PH3104, PH3122

List of Experiments

1. To draw the Characteristic Curves and DC Load Line for a CE Transistor and Determination of Hybrid Parameters.

Intended learning outcomes: Successful students should be able to:

(i) Identify the terminals and type of a transistor.
(ii) Determine the input and output characteristics of a CE transistor.
(iii) Draw the theoretical dc load line from the output characteristic curve.
(iv) Calculate the hybrid parameters.
(v) Understand the theoretical and experimental load lines.
(vi) Determine the operating points.

2. Construction and Study of a Phase Shift Oscillator.

Intended learning outcomes: Successful students should be able to:

(i) Understand the operation of a Phase Shift Oscillator.
(ii) Discuss how oscillations are initiated at first.
(iii) Explain necessary and sufficient conditions required to generate the sustainable oscillations.
(iv) Describe how to select frequency component of oscillator.
(v) Know relevant formula for the frequency of oscillation.
(vi) Compute the frequency of oscillation from component values.

3. Construction of a Transistorized Radio Receiver.

Intended learning outcomes: Successful students should be able to:

(i) Understand the basic function and characteristics of a radio receiver.
(ii) Draw a block diagram of a simple Radio receiver and explain the function of each block.
(iii) Draw the circuit diagram and analyze the function of each component.

(iv) Construct the circuit and test receiving signals transmitted by the local radio broadcasting center.

4. Construction of a Transistorized Radio Transmitter.

Intended learning outcomes: Successful students should be able to:

(i) Understand AM and FM signals.
(ii) Draw the circuit and analyze the function of each component.
(iii) Construct the circuit and test its performance using a commercial radio receiver set.

Books Recommended

Text Books

Chowdhury, SA and Basak, AK	ByaboharikPadarthavidya(*in Bangla*)
Tyler, F	Laboratory Manual of Physics
Worsnop, BL and Flint, HT	Advanced Practical Physics
Bar, Z and Malvino, AP	A Text Lab. Manual: Basic Electronics
Tout, E & Jansen, GJ	Practical Structure Determination

4th Year 1st Semester

PH4101 QUANTUM MECHANICS-III	(~28 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: ***50*** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***2*** *hours*

Prerequisites: PH2211, PH3102, PH3103, PH3202

Course Objectives and Summary: This is an advanced quantum mechanics course. This course will equip the students with the tools of matrix formulation of quantum mechanics and a thorough understanding of the role of operators in the Hilbert space for problem solving. The importance of the transformation theory has been highlighted. An introduction to relativistic quantum mechanics is also included.

1. **Matrix Formulation of Quantum Mechanics:** State Vectors in Hilbert Space; Bra and Ket Notations; Operators and their Representation; Unitary Transformations; Schrödinger, Heisenberg and Dirac Representations; Density Matrix; Parity Operators and Conservation of Parity, Harmonic Oscillator.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Explain the concept of state vectors in Hilbert space.
   - **(ii)** Construct matrix elements of an operator.
   - **(iii)** Transform different representations by using unitary operators.
   - **(iv)** Calculate the density matrix of a system.
   - **(v)** Solve one-dimensional harmonic oscillator problem using matrix formalism.
   - **(vi)** Derive equation of motion for various operators.
   - **(vii)** Explain parity and its conservation.

2. **Theory of Angular Momentum:** Eigenvalues of Angular Momentum; Addition of Angular Momenta; Clebsch-Gordon Coefficients; Pauli's Exclusion Principle and Spin Matrices.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Calculate commutator brackets for different angular momenta operators.
   - **(ii)** Employ ladder operators to obtain off-diagonal angular momenta matrices.
   - **(iii)** Obtain Pauli spin matrices.
   - **(iv)** Understand the necessity of Clebsch-Gordon coefficients and their selection rules.
   - **(v)** Visualize the coupling of spin system using Clebsch-Gordon coefficients.

3. **Relativistic Wave Equations:** Klein-Gordon and Dirac's Relativistic Wave Equation; Solution of Free Particle Equations; Equation of Continuity and its Consequences; Negative Energy States and Hole Theory; Spin-Orbit Interaction.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Solve Klein-Gordon equation.
   - **(ii)** Solve Dirac free particle equation.
   - **(iii)** Obtain Dirac matrices.
   - **(iv)** Understand Dirac's hole theory and the concept of antiparticles.

Books Recommended

Text Books

Schiff, LI	Quantum Mechanics
Merzbacher, E	Quantum Mechanics
Griffiths, DJ	Introduction to Quantum Mechanics
Mathews, PM and Venkatesan, K	Text Book of Quantum Mechanics
Bransden, BH and Joachain, CJ	Quantum Mechanics
Zettili, N	Quantum Mechanics: Concepts and Applications

Reference Books

Blokhintsev, DI	Fundamentals of Quantum Mechanics
Brink, DM and Satchler, GR	Angular Momentum
Bhuiyan, GM	Quantum Mechanics
Dirac, PAM	Principles of Quantum Mechanics
Edmonds, AR	Angular Momentum in Quantum Mechanics
Goldberger, ML and Watson, KM	Collision Theory
Golder, S	Quantum Balobidya (Bengali)
Landau, LD and Lifshitz, EM	Quantum Mechanics
Messiah, A	Quantum Mechanics
Pauling, L and Wilson, EB	Introduction to Quantum Mechanics
Powell, JL and Crasemann, B	Quantum Mechanics
Rashid, AMH	Quantum Mechanics
Ziock, C	Basic Quantum Mechanics
Sakurai, JJ	Modern Quantum Mechanics
Shankar, R	Principles of Quantum Mechanics
Cohen-Tannoudji,C, et al.	Quantum Mechanics (Vols. I and II)

PH4102 STATISTICAL MECHANICS-II (~28 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: **50** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* **2** *hours*

Prerequisites: PH3203

Course Objectives and Summary: The course gives an introduction to statistical mechanics with an emphasis on applications to quantum mechanical systems. It discusses exchange degeneracy, Fermi energy, quantum statistical equilibrium, and various properties of Fermi and Bose systems, including magnetism, superfluidity etc.

1. **Quantum Statistical Mechanics:** Pure and Mixed Quantum States; Postulates of Quantum Statistical Mechanics; Transition from Classical to Quantum Statistical Mechanics; Indistinguishability and Quantum Statistics; Exchange Symmetry of Wave Functions; Exchange Degeneracy; Average Value and Quantum Statistics; Statistics of Quantum Mechanical Ensembles.

   Intended learning outcomes: Enables successful students to:
   (i) Understand and explain the postulates of quantum statistical mechanics.
   (ii) Apply the concept of distinguishability on various systems of interest.
   (iii) Explain the transition from classical to quantum statistical mechanics and vice versa.
   (iv) Calculate ensemble average of a dynamical variable (operator).
   (v) Construct symmetric and anti-symmetric wave functions.

2. **Fermi Systems:** Fermi-Dirac Distribution Function; Fermi Energy; Fermi Temperature; Fermi Velocity and Mean Velocity of a Free Electron in a Metal; Degenerate Fermi System; Pauli Paramagnetism; Electronic Heat Capacity of Metals; Thermionic Emission; Photoelectric Current Density; Hydrostatic Equilibrium in White Dwarfs.

   Intended learning outcomes: Enables successful students to:
   (i) Calculate thermodynamic probability for a system of fermions.
   (ii) Derive Fermi-Dirac statistics (FDS).
   (iii) Apply FDS to calculate average energy and total energy of system of fermions.
   (iv) Determine Pauli spin susceptibility.
   (v) Explain stability of compact stars.
   (vi) Calculate thermionic and photoelectric current densities.

3. **Bose Systems:** Bose-Einstein Distribution Function; Applications: Photon Gas; Phonon Gas; Bose-Einstein Condensation; Superfluidity in Liquid He, Thermodynamics of Bose Systems. Thermodynamic Properties of Diatomic Molecules; Nuclear Spin Effects in Diatomic Molecules.

   Intended learning outcomes: Enables successful students to:
   (i) Calculate thermodynamic probability for a system of bosons.
   (ii) Derive Bose-Einstein statistics (BES).
   (iii) Apply BES to calculate energy densities for photons and phonons.
   (iv) Calculate lattice specific of solids.
   (v) Explain Bose-Einstein condensation (BEC) at qualitative and quantitative level.
   (vi) Estimate BEC temperature.
   (vii) Explain the basic features of diatomic molecules due to nuclear spin configuration.
   (viii) Explain the origin of superfluidity.

Books Recommended

Text Books

Pathria, RK	Statistical Physics
Huang, K	Statistical Mechanics
Reif, B	Fund. of Statistical and Thermal Physics
Gupta, SL et al.	Elementary Statistical Mechanics

Brijlal, L et al.	Thermal and Statistical Physics
Kardar, M	Statistical Mechanics of Particles

Reference Books

Berkeley Physics Course, V	Statistical Physics
Kittel, C and Kroemer, H	Thermal Physics
Stowe,K	Introduction to Statistical Mechanics
Pointon, AJ	Introduction to Statistical Physics
Singh, K et al.	Elements of Statistical Mechanics
Allis, WP and Herlin, MA	Thermodynamics and Statistical Mechanics
Riedl, PC	Thermal Physics
Saha, MN and Srivastava, BN	Treatise on Heat
Beiser, A	Concept of Modern Physics
Constant, FW	Theoretical Physics 2
Sears FW and Salinger, GL	Thermodynamics, Kinetic Theory & Statistical Mechanics
Agarwal, BK and Eisner, M	Statistical Mechanics

PH4103 NUCLEAR PHYSICS-II (~28 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: **50** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* **2** *hours*

Prerequisites: PH3205, PH3206

Course Objectives and Summary: This course aims to provide the concepts of nuclear physics focusing on characteristics of nuclear two-body interaction, nuclear models and nuclear reaction mechanisms.

1. **Nuclear Two-body Systems and Nuclear Forces:** Ground State of Deuteron; Normalization of Deuteron Wave Function; Non-existence of Excited States of Deuteron; Tensor Force; Low-Energy n-p Scattering; Determination of Phase Shift; Spin Dependence; Scattering Length; Effective Range Theory.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Apply quantum mechanics to calculate properties of two-body bound nuclear system, namely deuteron.
   - **(ii)** Identify consequences of the non-central features of nuclear force.
   - **(iii)** Calculate phase-shifts and scattering cross-sections for low-energy n-p scattering.
   - **(iv)** Apply the concept of scattering length to n-p scattering.
   - **(v)** Describe n-p scattering in terms of the effective range theory.

2. **Nuclear Models:**

   a) Liquid Drop Model: Semi-empirical Mass Formula; Most Probable Isotope.

a) Fermi Gas Model: Fermi Momentum; Average Energy of Nucleons in Nuclear Matter.

b) Nuclear Shell Model: Single Particle Potentials; Spin-Orbit Potential; Magic Numbers; Shell Model Predictions; Ground Stare Spins; Spin and Magnetic Moments of Nuclei; Schmidt Curves.

Intended learning outcomes: Enables successful students to:

(i) Understand the salient features of different models to explain the basic nuclear properties.

(ii) Predict angular momentum, parity, and magnetic dipole moment of nuclei, on the basis of single-particle configurations.

(iii) Calculate average energy of nucleon in nuclear matter.

3. **Nuclear Scattering and Reactions:** Optical Model: Complex Potential; Energy Averaged Cross-sections; Phenomenological Optical Model Cross-sections by Method of Partial Waves; Compound Nuclear Reactions; Continuum Theory; Resonance; Breit-Wigner Dispersion Formula for $l = 0$.

Intended learning outcomes: Enables successful students to:

(i) Employ optical model to calculate nuclear reaction cross-sections.

(ii) Compare and contrast among different reaction mechanisms in relation to cross-sections, excitation functions, and angular-distributions.

(iii) Comprehend the compound nuclear reaction and calculate the Q-values of reactions.

Books Recommended

Text Books

Enge, HA	Introduction to Nuclear Physics
Roy, RR and Nigam, BP	Nuclear Physics

Reference Books

Sen Gupta, HM	Nucleo Padartha Bidya *(in Bangla)*
Islam, GS	Paramanbik Ebong Nucleo Padarthabijnan, Vol.1
Segre, E	Nuclei and Particles
Cohen, BL	Concept of Nuclear Physics
Blatt, JM and Weiskopff, VF	Theoretical Nuclear Physics
Elton, LRB	Introductory Nuclear Theory

PH4104 SOLID STATE PHYSICS II (~28 *contact hours)*

Course Type: Core *Credit Point: 2*

Full Marks: **50** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* **2** *hours*

Prerequisite: PH3104

Course Objectives and Summary: This course explains the concepts that are used to describe the structure and physical properties of solids and uses physical models to perform calculations of the application related physical phenomena. This course includes description of electronic structure, structural and physical properties of metals, semiconductors, dielectrics, magnetic materials and superconductors based on the classical and quantum physics principles.

1. **Dielectric Properties:** Macroscopic Electric Field; Local Electric Field at an Atom; Dielectric Constants and Polarizabilities; Clausius-Mossotti Relation; Dielectric Phenomena in an AC Field; Debye Equations for Dielectric Constant and Dielectric Loss; Dielectric Response of an Electron Gas - Concept of Plasmon; Screened Coulomb Potential.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Calculate dielectric constants and polarizabilities.
   - **(ii)** Derive Debye equations for dielectric constants.
   - **(iii)** Derive an expression for screened Coulomb potential.
   - **(iv)** Understand the concept of plasmon and calculate the plasma frequency.

2. **Ferroelectricity and Piezoelectricity:** Ferroelectrics; Ferroelectric Phase Transitions; Ferroelectric Domains; Ferroelectric Materials: Classification and Applications; Piezoelectrics; Piezoelectric Materials: Types and Applications.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Understand the concept of ferroelectricity compared with ferromagnetism.
   - **(ii)** Learn the dynamics of the domain wall by an electric field.
   - **(iii)** Briefly explain the reason for obtaining the piezoelectric effect in solids.
   - **(iv)** Find out the uses of those materials in various fields.

3. **Magnetism:** Types of Magnetism and their Origins; Langevin Equation for Dia- and Paramagnetism; Curie Law; Quantum Theory of Paramagnetism; Hund's Rules; Quenching of Orbital Angular Momentum; Ferromagnetism; Weiss Molecular Field and Exchange Integral; Magnetic Domain and Bloch Wall; Antiferromagnetism; Neel's Theory; Two Sublattice Model; Ferrimagnetism and Structure of Ferrites and Garnets; Uses of Various Magnetic Materials; Magnetic Anisotropy; Magnetic Resonance.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Explain the physical origins of different types of magnetism.
   - **(ii)** Calculate the diamagnetic susceptibility.
   - **(iii)** Apply Hund's rules to calculate the effective number of Bohr magnetons.
   - **(iv)** Derive expressions for paramagnetic susceptibilities.
   - **(v)** Explain the magnetic domain dynamics.
   - **(vi)** Derive an expression for Neel temperature.
   - **(vii)** Explain the magnetic properties of ferrites and garnets and identify their scope of applications.
   - **(viii)** Explain magnetic resonance, describe the arrangement for NMR measurement, and understand its utility.

4. **Superconductivity:** Basic Properties of Superconductors; Meissner Effect; Type I and Type II Materials; Thermal and Electromagnetic Properties of Superconductors; Elementary Idea of BCS Theory.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Understand the basic features of superconductivity.
   - **(ii)** Classify superconductors according to their magnetic response.
   - **(iii)** Explain the thermal and electromagnetic properties of superconductors.
   - **(iv)** Explain the ideas behind BCS theory.

Books Recommended

Text Books

Kittel, C	Introduction to Solid State Physics
Dekker, AJ	Solid State Physics
Omar, MA	Elementary Solid State Physics
Bain, AK and Chand, P	Ferroelectrics: Principles and Applications
Alloul, H	Intro. to the Physics of Electrons in Solids
Brailsford, F	Physical Principle of Magnetism
Chikazumi, S	Physics of Magnetism

Reference Books

Kresin, VZ and Wolf, SA	Fundamentals of Superconductivity
Wahab, MA	Solid State Physics
Mitin, VV, Kochelap, VA and Stroscio, MA	Quantum Heterostructures: Microelectronics and Optoelectronics
Bhattacharyya, P	Semiconductor Optoelectronics Devices
Wert, CA and Thomson, RM	Physics of Solids

PH4105 PULSE AND DIGITAL ELECTRONICS (~42 contact hours)

Course Type: Core *Credit Point: 3*

Full Marks: **75** (*Written Examination 52.5, In-course Evaluation 15 and Attendance 7.5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* **2** *hours*

Prerequisites: PH3105, PH3106

Course Objectives and Summary: In-depth study of pulse processing especially needed in data conversions and storage in computing systems is presented in this course. The course provides the concepts, working principles and key applications of digital electronic circuits.

1. **Pulse Shaping:** Pulse Parameters; Linear Waveshaping: RC Integrator and RC Differentiator; Non-linear Waveshaping: Clipping and Clamping.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Characterize a given pulse using the concept of various pulse parameters, e.g. Pulse width, rise time, fall time etc.

- **(ii)** Design integrator and differentiator circuits for practical applications.
- **(iii)** Solve non-linear wave-shaping problems.
- **(iv)** Construct clipping and clamping circuits for specific needs.

2. Pulse Generators: Multivibrators: Astable, Monostable and Bistable, Schmitt Trigger, Blocking Oscillators and Time-Base Generators.

Intended learning outcomes: Enables successful students to:

- **(i)** Explain the functioning and utility of various multivibrators.
- **(ii)** Design and construct different multivibrators for specific needs.
- **(iii)** Design and construct Schmitt trigger, blocking oscillators, and time-base generators.

3. Fabrication of IC and Operational amplifiers: Fabrication of Integrated Circuits; Basic Principles of Operational Amplifiers; Inverting and Non-inverting Amplifier; Operational Amplifier: Summer, Subtractor, Integrator, Differentiator and Active Filters.

Intended learning outcomes: Enables successful students to:

- **(i)** Describe how ICs are fabricated.
- **(ii)** Explain in detail the working principle of OP amps.
- **(iii)** Design and construct summer, subtractor, integrator, differentiator, and active filter circuits.

4. Logic and Arithmetic Circuits: DDL and TTL Circuits, Truth Tables and Maps, Arithmetic Building Block- Half-Adder, Full-Adder, The Adder-Subtractor.

Intended learning outcomes: Enables successful students to:

- **(i)** Design and construct logic circuits
- **(ii)** Construct truth tables
- **(iii)** Understand half-adder and full adder

5. Data Conversion: Decoder, Encoder, Multiplexer, Demultiplexer, Code Converter, Analog-Digital Conversion (ADC) and Digital-Analog Conversion (DAC); Digital Multimeters.

Intended learning outcomes: Enables successful students to:

- **(i)** Explain the functions and constructions of all these data conversion systems.
- **(ii)** Explain the functions and constructions of digital multimeters.

6. Sequential Logic Circuits: Flip-flops: NAND Gate Latch; NOR Gate Latch; R-S Flip-flop; D Flip-flop; J-K Flip-flop; Master/Slave Flip-flop; T Flip-flop.

Intended learning outcomes: Enables successful students to:

- **(i)** Explain the functions and constructions of NAND and NOR gate latches.
- **(ii)** Explain the functions and constructions of all these flip-flops.

7. Counters: Synchronous and Asynchronous Counters; Up-Down Counters; Shift-Register and Frequency Counters; Digital Clock.

Intended learning outcomes: Enables successful students to:

- **(i)** Explain the functions and constructions of various counters.
- **(ii)** Explain the functions and constructions digital clock.

8. Memory Elements: RAM, ROM, EPROM, Static and Dynamic Access Memories; Magnetic Disk; MRAM.

Intended learning outcomes: Enables successful students to:
- **(i)** Explain the functions and constructions of various memory elements.
- **(ii)** Explain digital recording techniques.

Books Recommended

Text Books

Millman, J and Taub, H	Pulse, Digital and Switching Waveforms
Tocci, RJ	Digital System Principles & Applications
Mottershead, A	Electronic Devices and Circuits: An Introduction
Blitzer, R	Introduction to Pulse Shaping Circuits
Faulken, B	An Intro. To Op-Amplifiers with Linear Applications

Reference Books

Malvino, AP	Electronic Principles
Millman, J and Halkias, CC	Integrated Electronics: Analog and Digital Circuits and Systems
Gothman, WH	Digital Electronics: An Introduction to Theory and Practice
Bartee, T	Digital Computer Fundamentals
Taub, H and Schilling, DL	Digital Integrated Circuits
Malvino, AP and Leach, R	Digital Principles and Applications

PH4106 REACTOR PHYSICS (~28 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: ***50*** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***2*** *hours*

Prerequisite: PH3205

Course Objective and Summary: This course deals with nuclear reactions involving thermal and fast neutrons. Reactor fuel, reactor theory, reactor control and energy removal from the core of the reactor system are also discussed in this course.

1. **Neutron Reactions:** Interaction of Neutrons with Matter; Neutron Cross-section and its Determination; Yields and Mass Distribution; Energy Dependence of Neutron Cross-section; Fission Cross-section.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Calculate the energy dependent neutron reaction cross-section.
   - **(ii)** Explain the fission process.
   - **(iii)** Estimate the energy yield in a fission reaction.

2. **Diffusion and Slowing Down of Neutrons:** Thermal Neutron Diffusion; Diffusion Equations; Fast Neutron Diffusion and Fermi Age Equation; Energy Distribution and Cross-section of Thermal Neutrons; Slowing down of Neutrons; One Group Critical Equation and Reaction Buckling.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Deduce neutron diffusion equation and obtain the solutions.
   - **(ii)** Solve and understand Fermi age equation.
   - **(iii)** Calculate the neutron flux distribution in a nuclear reactor.
   - **(iv)** Describe neutron slowing down process in a reactor.
   - **(v)** Calculate the required multiplication factor to keep a reactor critical.

3. **Reactor Theory:** Multiplication Factors; Four-Factor Formula; Neutron Leakage and Critical Size; Calculation of K_∞ for Homogeneous & Heterogeneous Reactors; Classification of Reactors: Research Reactors Swimming Pool, TRIGA, Power Reactors, Pressurized Water Reactor, Boiling Water Reactor, Water-Water Energetic Reactor (WWER).

   Intended learning outcomes: Enables successful students to:
   - **(i)** Explain multiplication factor.
   - **(ii)** Employ four-factor formula for reactors.
   - **(iii)** Classify nuclear reactors.
   - **(iv)** Calculate the amount of thermal and electrical energies produced in a fission reactor.
   - **(v)** Design a fission power plant.

4. **Non-Steady Nuclear Reactor:** Thermal Life-Time and Generation Time; Time Dependent Reactor Equation; Excess Reactivity and Reactor Period; Effect of the Delayed Neutrons; Delayed Neutrons and Reactor Periods; Fission Product Poisoning; Burnable Poisons.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Understand thermal life-time and generation time.
   - **(ii)** Solve time dependent reactor equation.
   - **(iii)** Calculate excess reactivity and reactor period.
   - **(iv)** Learn about fission product poisoning and their management.

5. **Operation of Nuclear Reactors:** Reactor Kinematics, General Features of Reactor Control; Effect of Temperature on Reactivity; Design of the Control System and Reactor Operation; Fission Product Poisoning; Burnable Poisons; Reactor Safety and Case Studies.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Understand how the control system work in a reactor core.
   - **(ii)** Describe the dependence of temperature on reactivity.
   - **(iii)** Explain the functioning of control rods.
   - **(iv)** Decide what is to be done in any emergency situation

6. **Energy Removal:** Thermal Problems in Reactor Design; Design of Cooling System; Heat Sources in Reactor Systems; Reactor Coolants.

   Intended learning outcomes: Enables successful students to:

(i) Identify thermal problems in reactor design.
(ii) Design the layout for cooling system.
(iii) Choose appropriate reactor coolant.

7. **Reactor Fuels:** Fuel Cycle; Production of Reactor Fuels; Sources of Uranium; Separation of Uranium Isotopes; Re-Processing of Irradiated Fuel; Radioactive Waste Disposal.

Intended learning outcomes: Enables successful students to:
(i) Explain the reactor fuel cycle.
(ii) Describe production of reactor fuels.
(iii) Understand the re-processing procedure of irradiated nuclear fuel.
(iv) Generate a layout for radioactive waste disposal.

Books Recommended

Text Books

Liverhant, SE	Elementary Intro. to Nuclear Reactor Physics
Glasstone, S and Sesonske, A	Nuclear Reactor Engineering
Lamarsh, J	Introduction to Nuclear Reactor Theory
Lamarsh, JR	Introduction to Nuclear Engineering
Singal, RK	Nuclear Reactors

Reference Books

Stacey, WM	Nuclear Reactor Physics
Garg, S et al	Nuclear Reactor Physics
Murray, RL	Introduction to Nuclear Engineering
Islam, AKMA and Islam, A	Nucleo Padarthavijnan (*in Bangla*)
Jacobs, AM et al	Basic Principles of Nuclear Science and Reactors
Kesslev, G	Nuclear Fission Reactor
King, DG	Nuclear Power Systems

PH4107 PARTICLE PHYSICS (~28 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: ***50*** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***2*** *hours*

Prerequisite: PH3102, PH3202, PH3205.

Course Objective and Summary: This course deals with discrete symmetries, quantum numbers, quantum electrodynamics, parity and cp violations, and the basics of the standard model.

1. **Symmetries and Conservation Laws:** Classifications of Elementary Particles; Hadrons, Leptons and Quarks; Fundamental Interactions. Parity; Charge Conjugation; Time Reversal; CPT Theorem; G-Parity; Leptonic flavours and

lepton number; Quark flavours and baryonic number; Isospin; Strangeness Number and Charm.

Intended learning outcomes: Enables successful students to:

- **(i)** Explain discrete symmetries.
- **(ii)** Explain additive quantum numbers.

2. **Hadrons:** Resonances; The quark model; SU(3) Representations; Mesons; Baryons; Charm.

Intended learning outcomes: Enables successful students to:

- **(i)** Explain SU(3) representations.
- **(ii)** Explain the quark model of baryon.

3. **Quantum Electrodynamics:** The Feynman diagrams and QED; Feynman rules for QED; Lowest Order Inelastic and Elastic Process in QED; Obtaining Cross-sections; Analyticity and the need for antiparticles; The evolution of α.

Intended learning outcomes: Enables successful students to:

- **(i)** Explain the Feynman view of quantum electrodynamics.
- **(ii)** Test the basic features of QED.
- **(iii)** Learn about lowest order inelastic and elastic Process in QED

4. **Weak interactions:** Classification of weak interactions; Parity violation; Helicity and chirality; Measurement of the helicity of leptons; Violation of the C-parity; CP violation in kaon decay- The states of the neutral K system; Strangeness oscillations; Regeneration; CP violation and the system; Direct CP violation.

Intended learning outcomes: Enables successful students to:

- **(i)** Explain the basics of weak interactions.
- **(ii)** Explain Parity and CP violation.
- **(iii)** Learn about lowest order inelastic and elastic Process in QED

5. **The Standard Model:** The electroweak interaction; Structure of the weak neutral currents; Electroweak unification; The discovery of W and Z; The interaction between intermediate bosons; The search for the Higgs boson. Beyond Standard Model; Neutrino Oscillations.

Intended learning outcomes: Enables successful students to:

- **(i)** Explain the weak neutral currents.
- **(ii)** Explain the concept of electroweak unification.
- **(iii)** Visualize neutrino oscillations.

Books Recommended

Text Books

Bettini, A	Introduction to Elementary Particle Physics
Griffiths, D	Introduction to Elementary Particles
Halzen, F and Martin, AD	Quarks and Leptons: An Intro. with Applications
Mann, R	Introduction to Particle Physics and the Standard Model
Burcham, WE and Jobes, M	Nuclear and Particle Physics

Reference Books

Perkins, DH	Introduction to High Energy Physics

Lichtenberg, DB	Unitary Symmetry and Elementary Particles
Dodd, J and Gripaios, B	Ideas of Particle Physics
Martin, B. R. and Shaw, G	Particle Physics

PH4121 NUCLEAR PHYSICS PRACTICAL (~56 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: ***50*** (*Continuous Assessment 15 marks, Attendance 5, Practical Exam 30 marks*)

(*1 day for Experiments*) *Examination duration:* ***6*** *hours*

Prerequisites: PH3205

List of Experiments

1. Determination of Resolving Time of a G-M Counter by Double Source Method.

Intended learning outcomes: Successful students should be able to:

- **(i)** Determine the resolving time of a G-M tube;
- **(ii)** Understand the necessity of double source method instead of single source method to determine resolving time;
- **(iii)** Understand the concept of resolving time in this experiment.

2. Determination of Efficiency of a G-M Tube for Beta Counting.

Intended learning outcomes: Successful students should be able to:

- **(i)** Demonstrate the operation of the G-M tube including the concepts of threshold voltage, operating voltage, quenching, plateau, avalanche, tube's geometrical structure and its circuit details.
- **(ii)** Explain the concept and interpret the conservation rules for beta decay.
- **(iii)** Explain the concept of stability of nucleus and radioactivity.
- **(iv)** Calculate the efficiency of a G-M counter.

3. Determination of the relative efficiency of a GM tube.

Intended learning outcomes: Successful students should be able to:

- **(i)** Illustrate the operation of the G-M tube including the concepts of threshold voltage, operating voltage, quenching, plateau, avalanche, tube's geometrical structure and its circuit details.
- **(ii)** Explain the concept of stability of nucleus and radioactivity.
- **(iii)** Explain the concept of beta and gamma decay.
- **(iv)** Interpret the conservation rules for beta decay.
- **(v)** Calculate the relative efficiency of a G-M counter.

4. Verification of Inverse Square Law for Gamma Rays and Comparison of Source Intensities.

Intended learning outcomes: Successful students should be able to:

- **(i)** Verify the inverse square law for gamma rays and determine the intensity of an unknown source;
- **(ii)** Apply the principle to calculate the radiation dose.

5. Determination of the Maximum Energy of Beta Particles Emitted from Source and Estimation of Thickness of an Unknown Foil.

Intended learning outcomes: Successful students should be able to:

- **(i)** Demonstrate the operation of the G-M tube including the concepts of threshold voltage, operating voltage, quenching, plateau, avalanche, tube's geometrical structure and its circuit details.
- **(ii)** Explain the energy spectrum of beta decay.
- **(iii)** Interpret the role of neutrino in beta decay.
- **(iv)** Illustrate the absorption of beta particles in matter.
- **(v)** Calculate the maximum energy of beta particles.

PH4122 ELECTRONICS PRACTICAL-III (~56 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: ***50*** (*Continuous Assessment 15 marks, Attendance 5, Practical Exam 30 marks*)

(*1 day for Experiments*) *Examination duration:* ***6*** *hours*

Prerequisites: PH4105

List of Experiments

1. Study of Linear and Non-Linear Waveshapings

Intended learning outcomes: Successful students should be able to:

- **(i)** Construct and analyze practical waveshaping circuits.
- **(ii)** Investigate the performance of integrators and differentiators on electrical signals using waveshaping circuits.

2. Construction and Study of an Emitter-follower (Common-Collector) Amplifier Circuit.

Intended learning outcomes: Successful students should be able to:

- **(i)** Use this circuit as a great voltage buffer due to the high current gain combined with near unity voltage gain of the circuit.
- **(ii)** Understand how this amplifier is used as an impedance matching circuit.

3. Construction and Study of Pulse Generators:

a) Astable Multivibrator.

b) Monostable Multivibrator.

Intended learning outcomes: Successful students should be able to:

- **(i)** Understand the function of the astable multivibrator to produce quasi- stable states of the circuit.
- **(ii)** Learn how the rounding-off of the rising edge of output pulse can be minimized.
- **(iii)** Measure the duty cycle from the output waveforms.

4. Construction and Study of a Schmitt Trigger Circuit using Transistor Op-amp.

Intended learning outcomes: Successful students should be able to:

- **(i)** Understand the functions of the Schmitt Trigger circuit and to convert noisy square waves, sine waves or slow edges inputs into clean square waves.
- **(ii)** Learn how the hysteresis or two different threshold voltage levels occur for the rising and falling edges.

5. Construction and Study of Logic Gates using Diodes and Transistors.

Intended learning outcomes: Successful students should be able to:

- **(i)** Investigate AND, OR, NOT, NAND and NOR gate operations.
- **(ii)** Understand the fundamental laws of Boolean algebra associated with the AND, OR, NOT, NAND and NOR operation
- **(iii)** Use of universality of NAND and NOR gates.

Books Recommended

Text Books

Bar, Z and Malvino, AP	A Text Lab. Manual: Basic Electronics
Millman, J and Taub, H	Pulse, Digital and Switching Waveforms
Blueler, E and Goldsmith, GJ	Experimental Nucleonics
Person, FJ and Osborne, RR	Practical Nucleonics
Stout, E and Jensen, GJ	Practical Structure Determination

4th Year 2nd Semester

PH4201 QUANTUM MECHANICS-IV (~28 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: ***50*** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***2*** *hours*

Prerequisites: PH3102, PH3202, PH4101

Course Objectives and Summary: This is an advanced quantum mechanics course. It contains an extended section on applications to quantum mechanical problems in terms of various approximation methods, and another section on scattering theory.

1. **Approximation Methods**
   - a. **Stationary Perturbation Theory:** Nondegenerate Case; First-Order Perturbation; Second-Order Perturbation; Degenerate Case.
   - b. **Variational Method:** Expectation Value of Energy; Application to Excited States; Linear Variation Function; Applications to Harmonic Oscillator; Hydrogen Atom and Helium Atom.
   - c. **WKB Approximation:** Classical Limit; Approximate Solutions and Asymptotic Nature of Solutions; Validity Criterion; Solutions near a Turning Point; Connection Formulae; Application to Bound States.
   - d. **Time-dependent Perturbation Theory:** Principle of the Method; Constant and Harmonic Perturbations; Fermi's Golden Rule; Radiative and Dipole Transitions; Selection Rules.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Choose an appropriate method from perturbation theory, variational method and WKB approximation for a problem.
   - **(ii)** Solve problems for energies and wave functions up to first order (second order for energies) in perturbation theory.
   - **(iii)** Choose suitable trial functions and obtain ground state energies using the variational method.
   - **(iv)** Use the WKB approximation and obtain quantization condition on energy/momentum for bound systems.
   - **(v)** Calculate transition rates up to first (or second) order.

2. **Theory of Scattering:** Scattering Cross-section; Partial Wave Analysis; Applications to Scattering by Square Well Hard Sphere and Coulomb Potential; Resonance Scattering; Optical Theorem; Born Approximation; Validity Criterion; Applications of Green's Function Technique; Examples.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Calculate scattering cross-sections for simple potentials.
   - **(ii)** Derive and apply the Born formula for the scattering amplitude.
   - **(iii)** Identify cases where the partial wave and Born approximation are applicable.

Books Recommended

Text Books

Schiff, LI	Quantum Mechanics
Merzbacher, E	Quantum Mechanics
Griffiths, DJ	Introduction to Quantum Mechanics
Mathews, PM and Venkatesan, K	Text Book of Quantum Mechanics
Bransden, BH and Joachain, CJ	Quantum Mechanics
Zettili, N	Quantum Mechanics: Concepts and Applications

Reference Books

Blokhintsev, DI	Fundamentals of Quantum Mechanics
Brink, DM and Satchler, GR	Angular Momentum
Bhuiyan, GM	Quantum Mechanics (Bengali)
Dirac, PAM	Principles of Quantum Mechanics
Edmonds, AR	Angular Momentum in Quantum Mechanics
Goldberger, ML and Watson, KM	Collision Theory
Golder, S	Quantum Balobidya (Bengali)
Landau, LD and Lifshitz, EM	Quantum Mechanics
Messiah, A	Quantum Mechanics
Pauling, L and Wilson, EB	Introduction to Quantum Mechanics
Powell, JL and Crasemann, B	Quantum Mechanics
Rashid, AMH	Quantum Mechanics
Ziock, C	Basic Quantum Mechanics
Sakurai, JJ	Modern Quantum Mechanics
Shankar, R	Principles of Quantum Mechanics
Cohen-Tannoudji,C, et al.	Quantum Mechanics (Vols. I and II)

PH4202 MATERIALS SCIENCE AND NANOSCALE PHYSICS (~28 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: **50** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* **2** *hours*

Prerequisite: PH1201, PH4104

Course Objectives and Summary: This course describes the elastic properties within/beyond the elastic limit of materials. An overview of the engineering materials is discussed. This course also includes the physics of materials at the reduced dimensions and the experimental tools for the characterization of nanomaterials.

1. **Elastic Properties and Hardness of Materials:** Elastic Constants and Moduli of Elasticity; Elastic Waves; Elastic and Plastic Deformations; Creep; Fatigue; Hardness Testing; Hardness Scales.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Find the number of elastic constants in the different crystals and connect these constants with the elastic moduli.
   - **(ii)** Deduce the elastic wave equations and find the elastic wave velocities in a particular direction.
   - **(iii)** Explain various forms of elastic and plastic deformations.
   - **(iv)** Understand the variation of creep rate with temperature/stress.
   - **(v)** Know the concept of the fatigue limit of a material.
   - **(vi)** Describe the arrangement for hardness testing.
   - **(vii)** Apply the understanding of elastic properties to practical situations.

2. **Engineering Materials:** Classification of Engineering Materials; Structures and Properties of Metallic Materials; Structures and Properties of Non-metallic Materials: Polymers; Portland Cement; Glassy-metals and Glass Ceramics; Refractories; Liquid Crystals: Structure and Classifications.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Classify engineering materials.
   - **(ii)** Describe the composition and structural features of engineering materials.
   - **(iii)** Design engineering material for specific needs.
   - **(iv)** Describe essential features of glass ceramics and identify their areas of application.
   - **(v)** Classify different phases of liquid crystals.

3. **Introduction to Nanostructures:** Physics of Nanostructures; Different forms of Nanostructures; The Electron Gas in 2D, 1D and 0D Systems; Density of States and Dimensionality; Surface Electron and Energy Density in Lower Dimensions.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Understand different degrees of confinement of nanostructures.
   - **(ii)** Compare the energy density of states in lower dimensions with bulk and link the concept to relate the conduction for nanoscale devices.
   - **(iii)** Learn how the electron/energy density is varied in nanostructures with the Fermi energy.

4. **Characterization of Nanomaterials and Applications:** Tools to Characterize Nanomaterials: Mechanical Controllable Break Junction (MCBJ), Scanning Tunnelling Microscope (STM); Fabrication and Applications of Nanomaterials: Quantum Dots; Carbon Nanotubes; Graphene.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Learn how to form nanostructures using these above-mentioned tools.
   - **(ii)** Briefly know the fabrication process of nanomaterials.
   - **(iii)** Study the different kinds of nanomaterials that have shown potential applications in nanotechnology.
   - **(iv)** Survey the literature to study the electronic properties of nanomaterials.

Books Recommended

Text Books

Khanna, OP	Materials Science and Metallurgy
Rangawala, SC	Engineering Materials
Murty, BS et al.	Textbook of Nanosci. and Nanotech.
Kittel, C	Introduction to Solid State Physics
Duart, M, Palma, M and Rueda, A	Nanotechnology for Microelectronics and Optoelectronics

Reference Books

Pascoe, KJ	Intro. to the Properties of Engg. Materials
Van Vleck, LH	Materials Science for Engineers
Smith, WH	Principles of Materials Sci. and Engg.
Yariv, A	Quantum Electronics
Rogers, B, Adams, J and Pennathur, S	Nanotech.: Understanding Small Systems

PH4203 CRYSTALLOGRAPHY (~ 28 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: ***50*** (*Written Examination 35, In-course Evaluation 10 and Attendance 5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***2*** *hours*

Prerequisite: PH3104, PH4104

Course objectives and summary: X-ray diffraction crystallography is well established and widely used in the field of materials characterization to obtain information on the atomic scale. Various diffraction methods play important role in this regard. Systematic absences and intensity statistics give information about the atomic arrangement and symmetry elements present in the unit cell. Symmetry elements help to determine space group of the crystalline sample. Physical processes of x-ray absorption are also used to extract structural and compositional information. All these topics are used to elucidate structure of the crystalline materials.

1. **Geometry of Crystalline State:** Crystal Symmetry; Point Group and Space Group; Reciprocal Lattice.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Classify different crystal systems according to their symmetry.
   - **(ii)** Draw Brillouin zones in reciprocal space for different crystal structures.

2. **Diffraction by Crystals:** Diffraction of X-Rays by Crystals; Laue and Bragg's Equation; Structure Factor.

   Intended learning outcomes: Enables successful students to:

- **(i)** Establish Bragg and Lau conditions for X-ray diffraction.
- **(ii)** Establish inequality relation to show why the white light is not diffracted when it falls upon a material.
- **(iii)** Employ these equations to determine crystal structure.
- **(iv)** Calculate the structure factor for different crystal systems.

3. **Experimental Collection of Diffraction Data:** Powder Method; Laue; Oscillation/Rotation; Weissenberg Methods of Collection of Data; Interpretation of Diffraction Photographs.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Understand and explain the experimental arrangements to obtain X-ray diffraction spectra.
   - **(ii)** Interpret diffraction patterns to elucidate underlying crystal structure, e.g. Inter planer spacing, identification of phases, Miller indices etc.

4. **Determination of Space Groups:** Symmetry of X-Ray Photographs; Systematic Absences; Intensity Statistics.

   Intended learning outcomes: Enables successful students to:
   - **(i)** Understand symmetry of X-ray pattern.
   - **(ii)** Identify and explain systematic absences.
   - **(iii)** Explain intensity statistics.

Books Recommended

Text Books

Woolfson, MM	Introduction to X-ray Crystallography
Azaroff, L	Elementary X-ray Crystallography
Woolfson, MM	Direct Methods in Crystallography
Buerger, MJ	Introduction to X-ray Crystallography

Reference Books

Lipton, H and Cochran, W	Crystalline State, Vol. III
Stout, GH and Jensen, LH	Practical Structure Determination
Cullity, BD	Elements of X-ray Crystallography
Agarwal, BK	X-ray Spectroscopy
Bonnele, C and Mande, C	Advances in X-ray Spectroscopy
Compton, AH and Allison, SK	X-ray in theory and Experiment
Buerger, MJ	Vector Space
Buerger, MJ	Crystal Structure Analysis

PH4204 MEDICAL AND RADIATION PHYSICS (~42 contact hours)

Course Type: GEd *Credit Point: 3*

Full Marks: **75** (*Written Examination 52.5, In-course Evaluation 15 and Attendance 7.5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***3*** *hours*

Prerequisites: PH3204, PH3205

Course Objectives and Summary: This course is aimed to illustrate the applications of physics to the various techniques of medical imaging. This course also provides the fundamental concept of radiation dosimetry, nuclear medicine, biological effects of radiation, radiation protection and radiotherapy for cancer treatment.

1. **Physics of Diagnostic and Interventional Radiology:** X-ray Imaging: Radiography & Mammography; CT; Gamma Cameras; Physics of MRI; Ultrasound Imaging; Doppler; PET.

   Intended learning outcomes: Enables successful students to:
   (i) Explain the working principles of modern imaging techniques.
   (ii) Have working knowledge about the scope of applications of these imaging devices.

2. **Physics of Nuclear Medicine:** Production of Radionuclides and Radiopharmaceuticals: Bateman Equation; Most Frequently used Radionuclides; Radionuclide Administration; Image Quality and Noise.

   Intended learning outcomes: Enables successful students to:
   (i) Describe the process of radioisotope production.
   (ii) Select the appropriate radionuclide and radiopharmaceuticals for treatment of a specific disease.
   (iii) Perform imaging and function test for various organs inside a human body.

3. **Radiation Dosimetry:** Particle Flux and Fluence; Energy Flux and Fluence; Linear and Mass Attenuation Coefficients; Mass Energy Transfer and Mass Energy Absorption Coefficients; Exposure; Kerma; Absorbed Dose; RBE; Quality Factor and Radiation Weighting Factor; Radiation Weighted Dose Units; LET; Internally Deposited Radioisotope; Calculations of Dose Rate from a Point and Distributed Sources.

   Intended learning outcomes: Enables successful students to:
   (i) Convert among different radiation units.
   (ii) Calculate radiation exposure, absorbed dose for different source strength and geometry.
   (iii) Calculate internal deposition of radioisotope.
   (iv) Explain and employ Bragg-Gray principle.

4. **Radiobiology:** Classification of Radiation in Radiobiology; Cell Cycle and Cell Deth; Effect of Cellular Radiation; Oxygen Effect; Radiosensitivity; Cell Survival Curve; Dose Response Curve; Stochastic and Non-stochastic Effects; Early and Late Effects of Radiation; Linear Quadrupole Model and α/β ratio; Fractionation, EQD_{2Gy}; Tumor Control Probability (TCP) and Normal Tissue Complication Probability (NTCP); Equivalent Uniform Dose (EUD).

   Intended learning outcomes: Enables successful students to:
   (i) Estimate dose-response characteristics.

- **(ii)** Explain direct and indirect action.
- **(iii)** Describe the changes in biological molecules due to radiation.
- **(iv)** Describe the effect of radiation on genes.

5. **Introduction to Radiation Therapy:** Principle of Radiation Therapy; Overview of Cancer Treatment; How Radiation Kills Cancer Cell; Radiation Therapy Equipment: Linac; Collimation of Photon and Electron Beams; MLC; CO-60 unit; Penumbra; Phantom; PDD Measurement; Isodose Chart; Basic Treatment Planning.

   Intended learning outcomes: Enables successful students to:

   - **(i)** Design teletherapy beam (x- and γ-ray) line
   - **(ii)** Develop idea regarding beam collimation and isodose distribution.

Books Recommended

Text Books

Cameron, JR and Skofronick, JG	Medical Physics
Hende, WR	Medical Radiation Physics
Johns, HE and Cunningham, JR	Physics of Radiology
Cember, H	Introduction to Health Physics

Reference Books

Sprawls, P	Physical Principles of Medical Imaging
Podgorsak, EB	Radiation Oncology Physics - A Handbook for Teachers and Students
Pedrose de Lima, JJ	Nuclear Medicine and Mathematics
Cesareo, R	Nuclear Analytical Techniques in Medicine
Turner, M	Principle of Radiation and Protection
Knoll, GF	Radiation Detection and Measurements
Glasstone, S	Source Book on Atomic Energy

PH4205 ASTRONOMY AND COSMOLOGY (~42 contact hours)

Course Type: Core *Credit Point: 3*

Full Marks: **75** (*Written Examination 52.5, In-course Evaluation 15 and Attendance 7.5*)

(*5 questions to be answered out of 8 questions*) *Examination duration:* ***3*** *hours*

Prerequisite: PH1212, PH1203, PH2203, PH3102

Course Objective and Summary: This course deals observational mechanics, physics of Earth-Moon system, planetary astronomy, stellar astronomy, Galactic and Extragalactic astronomy and cosmology.

1. **Observational Astronomy:** Celestial Sphere, Planets, Satellites, Stars, Constellations, Meteors, Comets etc., The Solar System, The Milky Way;

Instruments: Telescopes, Spectrograph, Radio-astronomy and Beyond (IR, UV, X-ray, Gamma-ray etc.); Space Exploration: Unmanned, Manned, Space Telescopes.

Intended Learning Outcomes: Enables successful students to

(i) Record data about the observable universe
(ii) Sketch how optical telescopes work, and specify the advantages of reflecting telescopes over refractors.

2. **Orbital Mechanics:** Planetary Orbits; Motion in Nearly Circular Orbit; The Virial Theorem; Limits on the Size of Orbits; Phases and Rotation of the Moon; Eclipses.

Intended Learning Outcomes: Enables successful students to

(i) Explain the physics of Keplerian orbits.
(ii) Explain motion in the central force fields.
(iii) Calculate Roche limit and Hill radius.
(iv) Explain phases and rotation of the Moon and eclipses.

3. **The Solar System:** The Overall layout of the Solar System; Terrestrial and Jovian Planets; Motions of the Planets; Formation of the Solar System; Travelling Through Solar System; Exoplanets.

Intended Learning Outcomes: Enables successful students to

(i) Explain the importance of comparative planetology to solar system studies.
(ii) Describe the overall scale and structure of the solar system.
(iii) Outline the theory of solar system formation that accounts for the overall properties of our planetary system.
(iv) Summarize the basic differences between the terrestrial and the jovian planets.

4. **Stellar Physics:** Hydrostatic Equilibrium; Spectral Classification; Hertzsprung–Russell Diagrams; The equations of Stellar Structure; The equation of State; Energy Generation in Stars; Stellar Model Building; The Main Sequence.

Intended Learning Outcomes: Enables successful students to

(i) Classify stars according to luminosity.
(ii) Describe stellar structure and its connections to stellar burning.
(iii) Explain the evolution of stars.

5. **Stellar Evolution and Stellar Remnants:** Stellar Evolution; White Dwarfs; The Physics of Degenerate Matter; The Chandrasekhar Limit; The Cooling of White Dwarfs; Supernovae and Neutron Stars; Pulsars; Black Holes.

Intended Learning Outcomes: Enables successful students to

(i) Explain why stars evolve off the main sequence.
(ii) Explain the physics of degenerate matter.
(iii) Explain the formation of White Dwarf, Neutron Star, and Black holes.

6. **The Milky Way and Other Galaxies:** Structure of the Milky Way; Galaxy Demographics; The Kinematics of the Milky Way; The Galactic Center; Active Galactic Nuclei and Quasars; Groups and Clusters of Galaxies.

Intended Learning Outcomes: Enables successful students to

(i) Describe the overall structure of the Milky Way Galaxy, and say how the various regions differ from one another.
(ii) Explain the importance of variable stars for measuring the size and shape of our Galaxy.
(iii) Explain the kinematics of the Milky Way.

7. **Cosmology:** Problems with Newtonian Cosmology**;** Hubble's law; Friedman equation; Cosmological Models, Density parameter; Deceleration parameter; Cosmological constant; Dark matter and its candidates; Dark energy; Cosmic microwave background; Inflation.

Intended Learning Outcomes: Enables successful students to

(i) State the cosmological principle, and explain its significance and observational underpinnings.
(ii) List and discuss the possible outcomes of the present cosmic expansion.
(iii) Say why astronomers think the expansion of the universe is accelerating, and discuss the cause.
(iv) Explain what dark energy implies for the composition and age of the universe.

Books Recommended

Text Books

Maoz, D	Astrophysics in a Nutshell
Carrol, BW and Ostlie, DA	An Introduction to Modern Astrophysics
Ryden, B and Peterson, BM	Foundations of Astrophysics
Chaisson,E and McMillan, S	Astronomy Today
Liddle, AR	An Introduction to Modern Cosmology
Beech, M	Introducing the Stars
Dodelson, S and Schmidt, F	Modern Cosmology

Reference Books

Shapiro, SL and Teukolsky, SA	Black Holes, White Dwarfs and Neutron Stars
Kippenhahn, R, Weigert, A and Weiss, A	Stellar Structure and Evolution
Hansen, CJ, Kawaler, SD and Trimble,V	Stellar Interiors: Physical Principles, Structure and Evolution
Kutner, ML	Astronomy: A Physical Perspective
Basu, B	An Introduction to Astrophysics
Ryan, SG and Norton, AJ	Stellar Evolution and Nucleosynthesis
Bambi, C and Dolgov, AD	Introduction to Particle Cosmolgy
Fitzpatrick, R	Introduction to Celestial Mechanics
Panel, S and Blumenthal, G	21st Century Astronomy

PH4221 SOLID STATE PHYSICS PRACTICAL (~56 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: **50** (*Continuous Assessment 15 marks, Attendance 5, Practical Exam 30 marks*)

(*1 day for Experiments*) *Examination duration:* ***6*** *hours*

Prerequisites: PH3104, PH4104, PH4203

List of Experiments

1. Determination of the Ferromagnetic Curie Temperature.

Intended learning outcomes: Successful students should be able to:

- **(i)** Understand the concept of Curie temperature, intrinsic magnetic moment, ferromagnetic material, paramagnetic and ferromagnetic material.
- **(ii)** Understand the concept of induced magnetism and magnetic susceptibility.
- **(iii)** Demonstrate Curie and Curie Weiss laws.
- **(iv)** Calculate the Curie temperature investigating emf-temperature and voltage gradient-temperature curves.

2. Determination of Energy Gaps of Si and Ge Crystal using Semiconductor Diode.

Intended learning outcomes: Successful students should be able to:

- **(i)** Understand the concept of intrinsic and extrinsic semiconductors.
- **(ii)** Demonstrate the concept of biasing and depletion layer.
- **(iii)** Calculate the energy band gap of semiconductor sample and investigate the voltage-temperature curve.

3. Studies of magnetic properties of a ferromagnetic sample using an oscilloscope.

Intended Learning outcomes: Enable successful students to:

- **(i)** Explain the distinction between **B** and **H** and their variation with each other.
- **(ii)** Explain the formation of hysteresis loop as a function of the alternating field.
- **(iii)** Calculate retentivity, coercivity, magnetic permeability, magnetic susceptibility and hysteresis loss and explain their variation in different materials.
- **(iv)** Demonstrate the uses of the ferromagnetic materials.

4. Studies of conductivity and activation energy of a semiconducting sample and measurement of TCR.

Intended Learning outcomes: Enable successful students to:

- **(i)** Know the differences among Boltzmann, Bose-Einstein and Fermi-Dirac statistics.
- **(ii)** Know the meaning of activation energy and carrier activation from valence band to conduction band happens in a sample.
- **(iii)** Demonstrate the change of conductivity behavior of a semiconducting sample due to heat energy.
- **(iv)** Understand the carrier generation mechanism in semiconducting sample.
- **(v)** Calculate the temperature coefficient of resistivity and graphical methods of solution of an equation to find experimental value.

5. Determination of Planck's Constant.

Intended learning outcomes: Successful students should be able to:

- **(i)** Understand the concept of photoelectric effect, work function, absorption, photon energy, anode and cathode.
- **(ii)** Understand the concept of photocell, diffraction grating, Colour filters.
- **(iii)** Calculate Planck's constant h, from the photoelectric voltages measured and investigate the voltage of the photocell ~ frequency of the irradiated light curve.

PH4222 ELECTRONICS PRACTICAL-IV (~56 contact hours)

Course Type: Core *Credit Point: 2*

Full Marks: **50** (*Continuous Assessment 15 marks, Attendance 5, Practical Exam 30 marks*)

(*1 day for Experiments*) *Examination duration:* **6** *hours*

Prerequisites: PH4105

List of Experiments

1. Construction and Study of a Transistorized Regulated Power Supply.

Intended learning outcomes: Successful students should be able to:

- **(i)** Investigate the effects of load resistance on series voltage regulation.
- **(ii)** Analyze power supply regulation to determine their performance criteria and limitations.

2. Construction and Study of Flip-flop (RS and JK) Operations.

Intended learning outcomes: Successful students should be able to:

- **(i)** Construct, analyze and troubleshoot circuits which incorporate sequential logic devices.
- **(ii)** To design a sequential logic circuit from basic gates and studies the operational function by simulating R-S flip-flops comprising of cross-coupled NOR gates and NAND gates accordingly.
- **(iii)** Design and construct a synchronous counter.

3. Study of Operational Amplifiers:

a) Determination of the CMRR and the Slew-rate;

b) Inverting, Non-inverting and Summing Amplifiers.

Intended learning outcomes: Successful students should be able to:

- **(i)** Investigate the performances of an op-amp chip (DIP package) in three ways:
  - ***a.*** Experimentally determine the gain of standard inverting and non-inverting op-amp circuits.
  - ***b.*** Compare experimental results with the ideal predictions.
  - ***c.*** Determine op-amp performance criteria and limitations.
- **(ii)** Demonstrate a circuit containing an operational amplifier can be used to perform mathematical operations.
- **(iii)** Demonstrate the application of an op-amp circuit is the voltage-follower, which serves as an isolator between two parts of a circuit.

4. Construction and Study of High-Pass and Low-Pass Active Filters using Op-Amps.

Intended learning outcomes: Successful students should be able to:

- **(i)** Sketch the frequency responses of high-pass, low-pass and band pass active filters, and to calculate their cut-off frequencies.
- **(ii)** Determine and interpret the limitations of frequency responses of active filter.

Text Books

Bar, Z and Malvino, AP Basic Electronics: A Text-Lab Manual:

Millman, J and Taub, H	Pulse, Digital and Switching Waveforms
Blueler, E and Goldsmith, GJ	Experimental Nucleonics
Person, FJ and Osborne, RR	Practical Nucleonics
Stout, E and Jensen, GJ	Practical Structure Determination

Academic Calendar

1st Year 1st Semester B.Sc. (Honours), Session: 2024-25, Examination: 2025

Class Starts	Class Ends	Exam starts

1st Year 2nd Semester B.Sc. (Honours), Session: 2024-25, Examination: 2025

Class Starts	Class Ends	Exam starts

2nd Year 1st Semester B.Sc. (Honours), Session: 2025-26, Examination: 2026

Class Starts	Class Ends	Exam starts

2nd Year 2nd Semester B.Sc. (Honours), Session: 2025-26, Examination: 2026

Class Starts	Class Ends	Exam starts

3rd Year 1st Semester B.Sc. (Honours), Session: 2026-27, Examination: 2027

Class Starts	Class Ends	Exam starts

3rd Year 2nd Semester B.Sc. (Honours), Session: 2026-27, Examination: 2027

Class Starts	Class Ends	Exam starts

4th Year 1st Semester B.Sc. (Honours), Session: 2027-28, Examination: 2028

Class Starts	Class Ends	Exam starts

4th Year 2nd Semester B.Sc. (Honours), Session: 2027-28, Examination: 2028

Class Starts	Class Ends	Exam starts