DEPARTMENT OF

PHYSICS

Curriculum and Syllabus for
Postgraduate Programme in
Physics (New and Renewable Energy)
Under Credit Semester System
(with effect from 2019 admissions)

St Berchmans College
Founded 1922
AUTONOMOUS | College with Potential for Excellence | Reaccredited by NAAC with A Grade
Affiliated to Mahatma Gandhi University, Kottayam, Kerala
Changanassery, Kottayam, Kerala, India-686101

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Acknowledgement

The Board of Studies in Physics (PG) acknowledges the contributions from all members in restructuring the Post Graduate Education in Physics. The abundant support and recommendations from the sub-groups for designing different courses has shaped this curriculum to this present nature.

We thank all for their benevolent support and cooperation to make this venture a success.

For the Board of Studies in Physics,

Dr Shajo Sebastian

(Chairman)

Members of Board of Studies in Physics

Chairman: Dr Shajo Sebastian, Head of the Department of Physics

Vice Chancellor's Nominee

1. Dr. Biju P.R. Associate Professor ,School of Pure and Applied Physics, MG University, Kottayam

External Experts

2. Dr. Antony Joseph , Professor , Dept of physics , University of Calicut, Malappuram
3. Dr. Charles Jose ,Assistant Professor, Department of Physics ,CUSAT,Kochi

Corporate Sector

4. Mr. Cecil Augustine, Associate Vice President –Business Development, Rays Future Energy India Pvt Ltd.

Distinguished Alumni

5. Dr. M T Jose, Scientist 'G', IGCAR ,Kalpakkom , Tamilnadu
6. Mr. Manoj N Senior Sub Divisional Engineer ,BSNL, Thiruvalla

Faculty from the Department

1. Dr. Issac Paul
2. Dr. Siby Kurien
3. Dr. Jacob Mathew M
4. Dr. K E Abraham
5. Dr. Gijo Jose
6. Dr. Sajith Mathews T
7. Mr. Ajai Jose
8. Dr. Joshy Jose
9. Mr. Justin John
10. Mr. Benny Joseph
11. Dr. Lijo Jose
12. Dr. Sinu P Mathew
13. Dr. Loji K Thomas

Programme Objective

The objective of the program is to correlate the fundamental concepts in physics, electronic instrumentation, and computational techniques with utilisation methods of renewable energy sources, which are existing in the natural world. The aim of the this course is to train post-graduate students to fill the gap between the growing industry demand for specialised renewable energy expertise and the skills currently available on the job market.

Programme Outcome

Upon completion of the programme, the student will have:

- Ability to recognize the useful renewable energy sources available in India.
- Ability to distinguish between sustainable energy sources and fossil energy sources with emphasis on wind and photovoltaic systems.
- Knowledge of the operating principals of renewable energy production from various renewable sources, at the laboratory scale.
- Ability to design simple small autonomous photovoltaic systems.

REGULATIONS FOR POSTGRADUATE (PG) PROGRAMMES UNDER CREDIT SEMESTER SYSTEM (SB-CSS-PG) 2019

1. SHORT TITLE

1.1 These Regulations shall be called St. Berchmans College (Autonomous) Regulations (2019) governing postgraduate programmes under Credit Semester System (SB-CSS-PG).

1.2 These Regulations shall come into force with effect from the academic year 2019 - 20 onwards.

2. SCOPE

2.1 The regulation provided herein shall apply to all regular postgraduate programmes, MA/MSc/MCom, conducted by St. Berchmans College (Autonomous) with effect from the academic year 2019 - 20.

3. DEFINITIONS

3.1 'University' means Mahatma Gandhi University, Kottayam, Kerala.

3.2 'College' means St. Berchmans College (Autonomous).

3.3 There shall be an Academic Committee nominated by the Principal to look after the matters relating to the SB-CSS-PG system.

3.4 'Academic Council' means the Committee consisting of members as provided under section 107 of the University Act 2014, Government of Kerala.

3.5 'Parent Department' means the Department, which offers a particular postgraduate programme.

3.6 'Department Council' means the body of all teachers of a Department in the College.

3.7 'Faculty Mentor' is a teacher nominated by a Department Council to coordinate the continuous evaluation and other academic activities of the Postgraduate programme undertaken in the Department.

3.8 'Programme' means the entire course of study and examinations.

3.9 'Duration of Programme' means the period of time required for the conduct of the programme. The duration of a postgraduate programme shall be four (4) semesters.

3.10 'Semester' means a term consisting of a minimum 90 working days, inclusive of tutorials, examination days and other academic activities within a period of six months.

3.11 'Course' means a segment of subject matter to be covered in a semester. Each Course is to be designed under lectures/tutorials/laboratory or fieldwork/seminar/project/practical/ assignments/evaluation etc., to meet effective teaching and learning needs.

3.12 'Course Teacher' means the teacher who is taking classes on the course.

3.13 'Core Course' means a course that the student admitted to a particular programme must successfully complete to receive the Degree and which cannot be substituted by any other course.

3.14 'Elective Course' means a course, which can be substituted, by equivalent course from the same subject and the number of courses required to complete the programme shall be decided by the respective Board of Studies.

3.15 The elective course shall be either in the fourth semester or be distributed among third and fourth semesters.

3.16 'Audit Course' means a course opted by the students, in addition to the compulsory courses, in order to develop their skills and social responsibility.

3.17 'Extra Credit Course' means a course opted by the students, in addition to the compulsory courses, in order to gain additional credit that would boost the performance level and additional skills.

3.18 Extra credit and audit courses shall be completed by working outside the regular teaching hours.

3.19 There will be optional extra credit courses and audit courses. The details of the extra credit and audit courses are given below.

Semester	**Course**	**Type**
I	Course on Mendeley Reference Management Software	Optional, Extra credit Grades shall be given
	Course on Basic Life Support System and Disaster Management	Compulsory, Audit Grades shall be given
First summer vacation	Internship/Skill Training	Optional, Extra credit Grades shall be given
Any time during the programme	Oral Presentation in National/International seminar	Optional, Extra credit
	Publication in a recognized journal with ISSN number	

3.20 'Project' means a regular research work with stated credits on which the student conducts research under the supervision of a teacher in the parent department/any appropriate research centre in order to submit a report on the project work as specified.

3.21 'Dissertation' means a minor thesis to be submitted at the end of a research work carried out by each student on a specific area.

3.22 'Plagiarism' is the unreferenced use of other authors' material in dissertations and is a serious academic offence.

3.23 'Seminar' means a lecture expected to train the student in self-study, collection of relevant matter from books and Internet resources, editing, document writing, typing and presentation.

3.24 'Tutorial' means a class to provide an opportunity to interact with students at their individual level to identify the strength and weakness of individual students.

3.25 'Improvement Examination' is an examination conducted to improve the performance of students in the courses of a particular semester.

3.26 'Supplementary Examination' is an examination conducted for students who fail in the courses of a particular semester.

3.27 The minimum credits, required for completing a postgraduate programme is eighty (80).

3.28 'Credit' (C) of a course is a measure of the weekly unit of work assigned for that course in a semester.

3.29 'Course Credit': One credit of the course is defined as a minimum of one (1) hour lecture/minimum of two (2) hours lab/field work per week for eighteen (18) weeks in a semester. The course will be considered as completed only by conducting the final examination.

3.30 'Grade' means a letter symbol (A, B, C etc.) which indicates the broad level of performance of a student in a course/semester/programme.

3.31 'Grade Point' (GP) is the numerical indicator of the percentage of marks awarded to a student in a course.

3.32 'Credit Point' (CP) of a course is the value obtained by multiplying the grade point (GP) by the credit (C) of the course.

3.33 'Semester Grade Point Average' (SGPA) of a semester is calculated by dividing total credit points obtained by the student in a semester by total credits of that semester and shall be rounded off to two decimal places.

3.34 'Cumulative Grade Point Average' (CGPA) is the value obtained by dividing the sum of credit points in all the courses obtained by the student for the entire programme by the total credits of the whole programme and shall be rounded off to two decimal places.

3.35 'Institution average' is the value obtained by dividing the sum of the marks obtained by all students in a particular course by the number of students in respective course.

3.36 'Weighted Average Score' means the score obtained by dividing sum of the products of marks secured and credit of each course by the total credits of that semester/programme and shall be rounded off to two decimal places.

3.37 'Grace Marks' means marks awarded to course/courses, in recognition of meritorious achievements of a student in NCC/NSS/ Sports/Arts and cultural activities.

3.38 First, Second and Third position shall be awarded to students who come in the first three places based on the overall CGPA secured in the programme in the first chance itself.

4. PROGRAMME STRUCTURE

4.1 The programme shall include two types of courses; Core Courses and Elective Courses. There shall be a project/research work to be undertaken by all students. The programme will also include assignments, seminars, practical, viva-voce etc., if they are specified in the curriculum.

4.2 Total credits for a programme is eighty (80). No course shall have more than four (4) credits.

4.3 **Project/dissertation**

Project/research work shall be completed by working outside the regular teaching hours except for MSc Computer Science programme. Project/research work shall be carried out under the supervision of a teacher in the concerned department. A student may, however, in certain cases be permitted to work in an industrial/research organization on the recommendation of the supervisor. There shall be an internal assessment and external assessment for the project/dissertation. The external evaluation of the Project/Dissertation shall be based on the individual presentation in front of the expert panel.

4.4 **Evaluations**

The evaluation of each course shall contain two parts.

i Internal or In-Semester Assessment (ISA)

ii External or End-Semester Assessment (ESA)

Both ISA and ESA shall be carried out using indirect grading. The ISA:ESA ratio is 1:3. Marks for ISA is 25 and ESA is 75 for all courses.

4.5 **In-semester assessment of theory courses**

The components for ISA are given below.

Component	Marks
Attendance	2
Viva	3
Assignment	4
Seminar	4
Class test	4
Model Exam	8
Total	**25**

4.6 Attendance evaluation of students for each course shall be as follows:

% of Attendance	Marks
Above 90	2
75 - 90	1

4.7 **Assignments**

Every student shall submit one assignment as an internal component for every course.

4.8 **Seminar**

Every student shall deliver one seminar as an internal component for every course. The seminar is expected to train the student in self-study, collection of relevant matter from the books and internet resources, editing, document writing, typing and presentation.

4.9 **In-semester examination**

Every student shall undergo at least two in-semester examinations one as class test and second as model examination as internal component for every theory course.

4.10 To ensure transparency of the evaluation process, the ISA mark awarded to the students in each course in a semester shall be published on the notice board according to the schedule in the academic calendar published by the College. There shall not be any chance for improvement for ISA. The course teacher and the faculty mentor shall maintain the academic record of each student registered for the course which shall be forwarded to the office of the Controller of Examinations through the Head of the Department and a copy shall be kept in the office of the Head of the Department for at least two years for verification.

4.11 **In-semester assessment of practical courses**

The internal assessment of practical courses shall be conducted either annually or in each semester. There shall be one in-semester examination for practical courses. The examination shall be conducted annually or in each semester. The components for internal assessment is given below.

Component	Marks
Attendance	2
Lab Test	15
Viva-Voce	5
Record	3
Total	**25**

Attendance evaluation of students for each course shall be as follows:

% of Attendance	Marks
Above 90	2
75 - 90	1

4.12 **End-semester assessment**

The end-semester examination in theory and practical courses shall be conducted by the College.

4.13 The end-semester examinations for theory courses shall be conducted at the end of each semester. There shall be one end-semester examination of three (3) hours duration in each lecture based course.

4.14 The question paper should be strictly on the basis of model question paper set by Board of Studies.

4.15 A question paper may contain short answer type/annotation, short essay type questions/problems and long essay type questions. Marks for each type of question can vary from programme to programme, but a general pattern may be followed by the Board of Studies.

4.16 Question Pattern for external theory examination shall be,

Section	Total No. of Questions	Questions to be Answered	Marks	Total Marks for the Section
A	14	10	2	20
B	8	5	5	25
C	5	3	10	30
			Maximum	**75**

4.17 Photocopies of the answer scripts of the external examination shall be made available to the students for scrutiny as per the regulations in the examination manual.

4.18 Practical examination shall be conducted annually or in each semester. Practical examination shall be conducted by one external examiner and one internal examiner. The question paper setting and evaluation of answer scripts shall be done as per the directions in the examination manual of the College. The duration of practical examination shall be decided by the Board of Studies.

4.19 Project/Dissertation evaluation shall be conducted at the end of the programme. Project/Dissertation evaluation shall be conducted by one external examiner and one internal examiner. The components and mark division for internal and external assessment shall be decided by the respective Board of Studies.

Components of Project Evaluation	Marks
Internal Evaluation	25
Dissertation (External)	50
Viva-Voce (External)	25
Total	**100**

4.20 Comprehensive viva-voce shall be conducted at the end of the programme. Viva-voce shall be conducted by one external examiner and one internal examiner. The viva-voce shall cover questions from all courses in the programme. There shall be no internal assessment for comprehensive viva-voce. The maximum marks for viva-voce is one hundred (100).

4.21 For all courses (theory and practical) an indirect grading system based on a seven (7) point scale according to the percentage of marks (ISA + ESA) is used to evaluate the performance of the student in that course. The percentage shall be rounded mathematically to the nearest whole number.

Percentage of Marks	Grade	Performance	Grade Point
95 and above	S	Outstanding	10
85 to below 95	A+	Excellent	9
75 to below 85	A	Very Good	8
65 to below 75	B+	Good	7
55 to below 65	B	Above Average	6
45 to below 55	C	Satisfactory	5
40 to below 45	D	Pass	4
Below 40	F	Failure	0

4.22 **Credit Point**

Credit Point (CP) of a course is calculated using the formula

$$\mathbf{CP = C \times GP}$$

where C is the credit and GP is the grade point

4.23 **Semester Grade Point Average**

Semester Grade Point Average (SGPA) is calculated using the formula

SGPA = TCP/TCS

where TCP is the total credit point of all the courses in the semester and TCS is the total credits in the semester

GPA shall be rounded off to two decimal places.

4.24 **Cumulative Grade Point Average**

Cumulative Grade Point Average (CGPA) is calculated using the formula

CGPA = TCP/TC

where TCP is the total credit point of all the courses in the whole programme and TC is the total credit in the whole programme

GPA shall be rounded off to two decimal places.

Grades for the different courses, semesters, Semester Grade Point Average (SGPA) and grades for overall programme, Cumulative Grade Point Average (CGPA) are given based on the corresponding Grade Point Average (GPA) as shown below:

GPA	Grade	Performance
9.5 and above	S	Outstanding
8.5 to below 9.5	A+	Excellent
7.5 to below 8.5	A	Very Good
6.5 to below 7.5	B+	Good
5.5 to below 6.5	B	Above Average
4.5 to below 5.5	C	Satisfactory
4 to below 4.5	D	Pass
Below 4	F	Failure

4.25 A separate minimum of 40% marks each in ISA and ESA (for theory and practical) and aggregate minimum of 40% are required for a pass in a course. For a pass in a programme, a separate minimum of grade 'D' is required for all the individual courses.

5. SUPPLEMENTARY/IMPROVEMENT EXAMINATION

5.1 There will be supplementary examinations and chance for improvement. Only one chance will be given for improving the marks of a course.

5.2 There shall not be any improvement examination for practical courses and examinations of the final year.

6. ATTENDANCE

6.1 The minimum requirement of aggregate attendance during a semester for appearing the end semester examination shall be 75%. Condonation of shortage of attendance to a maximum of ten (10) days in a semester subject to a maximum of two times during the whole period of postgraduate programme may be granted by the College. This condonation shall not be counted for internal assessment.

6.2 Benefit of attendance may be granted to students representing the College, University, State or Nation in Sports, NCC, NSS or Cultural or any other officially sponsored activities such as College union/University union activities etc., on production of participation/attendance certificates, within one week from competent authorities, for the actual number of days participated, subject to a maximum of ten (10) days in a semester, on the specific recommendations of the Faculty Mentor and Head of the Department.

6.3 A student who does not satisfy the requirements of attendance shall not be permitted to appear in the end-semester examinations.

6.4 Those students who are not eligible even with condonation of shortage of attendance shall repeat the course along with the next batch after readmission.

7. BOARD OF STUDIES AND COURSES

7.1 The Board of Studies concerned shall design all the courses offered in the programme. The Board shall design and introduce new courses, modify or re-design existing courses and replace any existing courses with new/modified courses to facilitate better exposure and training for the students.

7.2 The syllabus of a programme shall contain programme objectives and programme outcome.

7.3 The syllabus of a course shall include the title of the course, course objectives, course outcome, contact hours, the number of credits and reference materials.

7.4 Each course shall have an alpha numeric code which includes abbreviation of the course in two letters, semester number, course code and serial number of the course.

7.5 Every programme conducted under Credit Semester System shall be monitored by the Academic Council.

8. REGISTRATION

8.1 A student who registers his/her name for the external exam for a semester will be eligible for promotion to the next semester.

8.2 A student who has completed the entire curriculum requirement, but could not register for the Semester examination can register notionally, for getting eligibility for promotion to the next semester.

8.3 A student may be permitted to complete the programme, on valid reasons, within a period of eight (8) continuous semesters from the date of commencement of the first semester of the programme

9. ADMISSION

9.1 The admission to all PG programmes shall be as per the rules and regulations of the College/University.

9.2 The eligibility criteria for admission shall be as announced by the College/University from time to time.

9.3 Separate rank lists shall be drawn up for seats under reservation quota as per the existing rules.

9.4 There shall be an academic and examination calendar prepared by the College for the conduct of the programmes.

10. ADMISSION REQUIREMENTS

10.1 Candidates for admission to the first semester of the PG programme through SB-CSS-PG shall be required to have passed an appropriate degree examination of Mahatma Gandhi University or any University or authority, duly recognized by the Academic council of Mahatma Gandhi University as equivalent thereto.

11. MARK CUM GRADE CARD

11.1 The College under its seal shall issue to the students, a Mark cum Grade Card on completion of each semester, which shall contain the following information.

i. Name of the Student
ii. Register Number
iii. Photo of the Student
iv. Degree
v. Programme
vi. Semester and Name of the Examination

vii. Month and Year of Examination
viii. Faculty
ix. Course Code, Title and Credits of each course opted in the semester
x. Marks for ISA, ESA, Total Marks (ISA + ESA), Maximum Marks, Letter Grade, Grade Point (GP), Credit Point (CP) and Institution Average in each course opted in the semester
xi. Total Credits, Marks Awarded, Credit Point, SGPA and Letter Grade in the semester
xii. Weighted Average Score
xiii. Result
xiv. Credits/Grade of Extra Credit and Audit Courses

11.2 The final Mark cum Grade Card issued at the end of the final semester shall contain the details of all courses taken during the entire programme including those taken over and above the prescribed minimum credits for obtaining the degree. The final Mark cum Grade Card shall show the CGPA and the overall letter grade of a student for the entire programme.

11.3 A separate grade card shall be issued at the end of the final semester showing the extra credit and audit courses attended by the student, grade and credits acquired.

12. AWARD OF DEGREE

The successful completion of all the courses with 'D' grade shall be the minimum requirement for the award of the degree.

13. MONITORING COMMITTEE

There shall be a Monitoring Committee constituted by the Principal to monitor the internal evaluation conducted by the College. The Course Teacher, Faculty Mentor, and the College Coordinator should keep all the records of the continuous evaluation, for at least a period of two years, for verification.

14. GRIEVANCE REDRESS COMMITTEE

14.1 In order to address the grievance of students relating to ISA, a two-level grievance redress mechanism is envisaged.

14.2 A student can approach the upper level only if grievance is not addressed at the lower level.

14.3 Department level: The Principal shall form a Grievance Redress Committee in each Department comprising of course teacher and one senior teacher as members and the Head of the Department as Chairman. The Committee shall address all grievances relating to the internal assessment of the students.

14.4 College level: There shall be a College level Grievance Redress Committee comprising of Faculty Mentor, two senior teachers and two staff council members (one shall be an elected member) and the Principal as Chairman. The Committee shall address all grievances relating to the internal assessment of the students.

15. TRANSITORY PROVISION

Notwithstanding anything contained in these regulations, the Principal shall, for a period of three years from the date of coming into force of these regulations, have the power to provide by order that these regulations shall be applied to any programme with such modifications as may be necessary.

REGULATIONS FOR EXTRACURRICULAR COURSES, INTERNSHIP AND SKILL TRAINING

COURSE ON BASIC LIFE SUPPORT SYSTEM AND DISASTER MANAGEMENT (BLS & DM)

i. The course on BLS & DM shall be conducted by a nodal centre created in the college.

ii. The nodal centre shall include at least one teacher from each department. A teacher shall be nominated as the Director of BLS & DM.

iii. The team of teachers under BLS & DM shall function as the trainers for BLS & DM.

iv. The team of teachers under BLS & DM shall be given intensive training on Basic Life Support System and Disaster Management and the team shall be equipped with adequate numbers of mannequins and kits for imparting the training to students.

v. Each student shall under go five (5) hours of hands on training in BLS & DM organised by the Centre for BLS & DM.

vi. The training sessions shall be organised on weekends/holidays/vacation during the first semester of the programme.

vii. After the completion of the training, the skills acquired shall be evaluated using an online test and grades shall be awarded.

viii. Nodal centre for BLS & DM shall conduct online test and publish the results.

ix. Students who could not complete the requirements of the BLS & DM training shall appear for the same along with the next batch. There shall be two redo opportunity.

x. For redressing the complaints in connection with the conduct of BLS & DM students shall approach the Grievance Redress Committee functioning in the college.

COURSE ON MENDELY REFERENCE MANAGEMENT SOFTWARE

i. College shall arrange workshop with hands on training in Mendely reference management software during the first semester.

ii. Students completing the course can enrol for an evaluation and those who pass the evaluation shall be given one credit.

INTERNSHIP/SKILL TRAINING PROGRAMME

i. Postgraduate student can undergo an internship for a minimum period of five days (25 hours) at a centre identified by the concerned department. In the case of disciplines where internship opportunities are scanty (e.g. Mathematics) special skill training programmes with duration of five days (25 hours) shall be organised.
ii. Each department shall identify a teacher in charge for internship/skill training programme.
iii. The department shall select institutions for internship/organising skill training programme.
iv. Internship/skill training programme shall be carried out preferably during the summer vacation following the second semester or during the Christmas vacation falling in the second semester or holidays falling in the semester.
v. At the end of the stipulated period of internship each student shall produce an internship completion cum attendance certificate and an illustrated report of the training he/she has underwent, duly certified by the tutor and Head of the institution where the internship has been undertaken.
vi. Students undergoing skill training programme shall submit a training completion cum attendance certificate and a report of the training he/she has underwent, duly certified by the trainer, teacher co-ordinator of the programme from the concerned department and the head of the department concerned.
vii. Upon receipt of the internship completion cum attendance certificate and illustrated report of the training or a training completion cum attendance certificate and a report of the training, the teacher in charge of internship/skill training programme shall prepare a list of students who have completed the internship/skill training programme and a list of students who failed to complete the programme. Head of the department shall verify the lists and forward the lists to the Controller of Examinations.

PAPER PRESENTATION

i. During the period of the programme students shall be encouraged to write and publish research/review papers.
ii. One research/review paper published in a UGC approved journal or oral presentation in an international/national seminar which is later published in the proceedings shall fetch one credit.

VIRTUAL LAB EXPERIMENTS/MOOC COURSES

i. During the tenure of the programme, students shall be encouraged to take up Virtual Lab Experiments and/or MOOC Courses.
ii. College shall arrange dedicated infrastructure for taking up Virtual Lab experiments and/or MOOC courses.
iii. There shall be a Nodal Officer and a team of teachers to coordinate the logistics for conducting Virtual Lab experiments and MOOC courses and to authenticate the claims of the students regarding the successful completion of the Virtual Lab experiments and or MOOC courses.
iv. Students who are desirous to do Virtual Lab experiments and or MOOC courses shall register with the Nodal Officer at the beginning of the experiment session/MOOC course. Students also shall submit proof of successful completion of the same to the Nodal officer.
v. Upon receipt of valid proof, the Nodal Officer shall recommend, to the Controller of Examinations, the award of extra credits. In the case of Virtual Lab experiments, 36 hours of virtual experimentation shall equal one credit and in the case of MOOC courses 18 hours of course work shall equal one credit.

<u>**Model Mark cum Grade Card.**</u>

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MARK CUM GRADE CARD

Date:

Name of the Candidate :
Permanent Register Number (PRN) :
Degree :
Programme :
Name of Examination :
Faculty :

Photo

Course Code	Course Title	Credits (C)	Marks						Grade Awarded (G)	Grade Point (GP)	Credit Point (CP)	Institution Average	Result
			ISA		ESA		Total						
			Awarded	Maximum	Awarded	Maximum	Awarded	Maximum					
	Total **SGPA: SG: WAS:** *****End of Statement*****												

***WAS: Weighted Average Score**

Entered by:

Verified by:

Controller of Examinations **Principal**

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E-mail: sbc@sbcollege.org Web: www.sbcollege.ac.in

CONSOLIDATED MARK CUM GRADE CARD

Name of the Candidate :

Permanent Register Number (PRN) :

Degree :

Programme :

Faculty :

Date :

Photo

Course Code	Course Title	Credits (C)	Marks						Grade Awarded (G)	Grade Point (GP)	Credit Point (CP)	Institution Average	Result
			ISA		ESA		Total						
			Awarded	Maximum	Awarded	Maximum	Awarded	Maximum					
SEMESTER I													
SEMESTER II													
SEMESTER III													

SEMESTER IV													
	End of Statement												

PROGRAMME RESULT

Semester	Marks Awarded	Maximum Marks	Credit	Credit Point	SGPA	Grade	WAS	Month & Year of Passing	Result
I II III IV									
Total					**FINAL RESULT: CGPA = ; GRADE = ;WAS =**				

*** Separate grade card is issued for Audit and Extra Credit courses.**
**** Grace Mark awarded.**

Entered by:

Verified by:

Controller of Examinations **Principal**

Reverse side of the Mark cum Grade Card (COMMON FOR ALL SEMESTERS)

Description of the Evaluation Process

Grade and Grade Point

The evaluation of each course comprises of internal and external components in the ratio 1:3 for all Courses. Grades and Grade Points are given on a seven (7) point scale based on the percentage of Total Marks (ISA + ESA) as given in Table 1. Decimals are corrected to the nearest whole number.

Credit Point and Grade Point Average

Credit Point (CP) of a course is calculated using the formula

CP = C × GP

where C is the Credit and GP is the Grade Point

Grade Point Average of a Semester (SGPA) or Cumulative Grade Point Average (CGPA)for a Programme is calculated using the formula

SGPA or CGPA = TCP/TC

where TCP is the Total Credit Point for the semester/programme and TC is the Total Credit for the semester/programme

GPA shall be rounded off to two decimal places.

The percentage of marks is calculated using the formula;

$$\% \text{ Marks} = \left(\frac{\text{total marks obtained}}{\text{maximum marks}}\right) \times 100$$

Weighted Average Score (WAS) is the score obtained by dividing sum of the products of marks secured and credit of each course by the total credits of that semester/programme and shall be rounded off to two decimal places.

Percentage of Marks	Grade	Performance	Grade Point
95 and above	S	Outstanding	10
85 to below 95	A+	Excellent	9
75 to below 85	A	Very Good	8
65 to below 75	B+	Good	7
55 to below 65	B	Above Average	6
45 to below 55	C	Satisfactory	5
40 to below 45	D	Pass	4
Below 40	F	Failure	0

Table 1

Grades for the different Semesters and overall Programme are given based on the corresponding GPA, as shown in Table 2.

GPA	Grade	Performance
9.5 and above	S	Outstanding
8.5 to below 9.5	A+	Excellent
7.5 to below 8.5	A	Very Good
6.5 to below 7.5	B+	Good
5.5 to below 6.5	B	Above Average
4.5 to below 5.5	C	Satisfactory
4 to below 4.5	D	Pass
Below 4	F	Failure

Table 2

Note: Course title followed by (P) stands for practical course. A separate minimum of 40% marks each for internal and external assessments (for both theory and practical) and an aggregate minimum of 40% marks is required for a pass in each course. For a pass in a programme, a separate minimum of Grade D for all the individual courses and an overall Grade D or above are mandatory. If a candidate secures Grade F for any one of the courses offered in a Semester/Programme, only Grade F will be awarded for that Semester/Programme until the candidate improves this to Grade D or above within the permitted period.

PROGRAMME STRUCTURE

	Course Code	Course Title	Hours /Week	Total Hours	Credit	ISA	ESA	Total
Semester I	BMPN101	Mathematical Physics - I	4	72	4	25	75	100
	BMPN102	Classical Mechanics	4	72	4	25	75	100
	BMPN103	Electrodynamics, Special Theory of Relativity and Nonlinear Optics	4	72	4	25	75	100
	BMPN104	Advanced Electronics	4	72	4	25	75	100
		General Physics Practicals (P)	9	162	Evaluation in Semester II			
		Total	**25**	**450**	**16**	**100**	**300**	**400**
Semester II	BMPN205	Mathematical Physics – II	4	72	4	25	75	100
	BMPN206	Elementary Quantum Mechanics	4	72	4	25	75	100
	BMPN207	Statistical Mechanics and Chemical Thermodynamics	4	72	4	25	75	100
	BMPN208	Solid State Physics	4	72	4	25	75	100
	BMPN2P01	General Physics Practicals (P)	-	-	3	25	75	100
	BMPN2P02	Electronics Practicals (P)	9	162	3	25	75	100
		Total	**25**	**450**	**22**	**150**	**450**	**600**
Semester III	BMPN309	Advanced Quantum Mechanics	4	72	4	25	75	100
	BMPN310	Numerical Methods in Physics	4	72	4	25	75	100
	BMPN311	Renewable Energy Sources	4	72	4	25	75	100
	BMPN312	Microprocessors and Microcontrollers	4	72	4	25	75	100
		Computational Physics Practical (P)	9	162	Evaluation in Semester IV			
		Total	**25**	**450**	**16**	**100**	**300**	**400**
Semester IV	BMPN413	Atomic and Molecular Physics	4	72	4	25	75	100
	BMPN414	Advanced Nuclear Physics	4	72	4	25	75	100
	BMPN415	Solar Thermal Collection and Storage	4	72	4	25	75	100
		Elective Course	4	72	4	25	75	100
	BMPN4P03	Computational Physics Practical (P)	-	-	3	25	75	100
	BMPN4P04	Renewable Energy Practicals (P)	9	162	3	25	75	100
	BMPN4PJ	Project	Nil	Nil	2	25	75	100
	BMPN4VV	Viva Voce	Nil	Nil	2	-	100	100
		Total	**25**	**450**	**26**	**175**	**625**	**800**
		Grand Total	**-**	**-**	**80**	**525**	**1675**	**2200**

ELECTIVE COURSES

BMPN4E01	Solar Photovoltaics
BMPN4E02	Nonlinear Dynamics and Introduction to Chaos
BMPN4E03	Astrophysics and Cosmology

SEMESTER I

BMPN101: MATHEMATICAL PHYSICS – I

Total Hours: 72

Credit: 4

Course Objective: To provide students the ability to hone the mathematical skills necessary to approach problems in advanced physics courses.

Course Outcome:

- Students will be equipped to probe the models of physical world
- Mathematical structure of the governing laws in physics will be revealed
- They will also have an appreciation of generalized functions, their calculus and applications

Module I: Vector Analysis, Statistical probability and Error Analysis (20 Hours)

Rotation of the coordinate axes – Gradient, Divergence and Curl in integral form – Vector integration – Gauss' and Stokes and Green theorems – Potential theory – Gauss' law – Poisson's equation – Orthogonal curvilinear coordinates – Differential vector operators in Cartesian, cylindrical and spherical polar coordinates.

Elementary probability theory, Random variables, Binomial, Poisson and Gaussian distributions-central limit theorem, Propagation of errors, Plotting of graphs, Least square fitting, Goodness of fit, Chi square test.

Module II: Matrices (16 Hours)

Triangular, diagonal and band matrices – symmetric, Hermitian, orthogonal, unitary and normal matrices – Pauli spin matrices – linear transformations - similarity transformation - unitary and orthogonal transformations – eigen value problem – diagonalization of matrices using normalised eigen vectors – normal modes of vibration – solution of a set of linear equations by matrix inversion method, Gauss elimination method, Gauss-Jordan method – Gauss-Seidel method - Jacobi method.

Module III: Second Order Differential Equations and Green's Function (18 Hours)

Linear differential equations with constant coefficients- methods for finding complementary function- general method of finding the particular integral of any function

Partial differential equations in Physics – boundary conditions – separation of variables - (Cartesian, Spherical polar and Cylindrical coordinates) Helmholtz equation - heat equation -

Self-Adjoint ODEs - Hermitian operators and their properties – Schmidt orthogonalization – non-homogeneous equations – Green's function - 1-dimensional Green's function eigenvalue equation of Green's function and Dirac delta function.

Module IV: Differential Equations and Special Functions (18 Hours)

Series solution of linear second order differential equations – Frobenius method- Bessel function of the first kind (Generating function, Recurrence relations, Orthogonality), spherical Bessel function, Legendre polynomials, Hermite polynomials, Laguerre polynomials (Generating function, Recurrence relations, Orthogonality) – Rodrigues' formula. Beta, Gamma and Dirac Delta functions.

Reference

1. Mathematical Methods for Physicists, G.B. Arfken & H.J. Weber 4th Edition, Academic Press
2. Mathematical Physics, H.K Dass & R. Verma, S.Chand & Co.
3. Mathematical Physics, B.D. Gupta, Vikas Pub.House, New Delhi
4. Mathematical Physics, Sathyaprakash, Sultan Chand & Sons, New Delhi.
5. Mathematical Physics, B.S. Rajput, Y Prakash 9th Ed, Pragati Prakashan
6. Mathematical methods in Classical and Quantum Physics, T. Dass & S. K. Sharma, Universities Press (2009)
7. Advanced Engineering Mathematics, E. Kreyszig, 7th Ed., John Wiley
8. Introduction to Mathematical Methods in Physics, G. Fletcher, Tata McGraw Hill
9. Advanced Engineering Mathematics, C.R. Wylie, & L C Barrett, Tata McGraw Hill
10. Advanced Mathematics for Engineering and Physics, L.A. Pipes & L.R. Harvill, Tata McGraw Hill
11. Mathematical Methods in Physics, J. Mathew & R.L. Walker, India Book House.

BMPN102: CLASSICAL MECHANICS

Total Hours: 72

Credit: 4

Course Objective: The course aims to develop an understanding of Lagrangian and Hamiltonian formulation, which allow for simplified treatments of many complex problems in classical mechanics and provides the foundation for the modern understanding of dynamics.

Course Outcome

- Students will be able to design the mathematical models of the physical systems.
- The analytical problem solving skills will be extended to a general framework.
- Understanding of advanced level mathematical and geometrical structure of classical mechanics is implied.
- The capability of handling linear systems will be extended to solve nonlinear systems.

Module I: Lagrangian Dynamics (16 Hours)

Review of Newtonian mechanics-Constraints-Generalized coordinates -- The principle of least action-Hamiltons principle and Lagrange's equation-few applications of Lagrange equations- Symmetries of space and time - Conservation laws of, momentum , angular momentum and energy – Physics of central force-Deduction of two body problem to one body problem- First integral of motion under central force- Stability and closure of orbits under central force-virial theorem-scattering in a central force field.

Module II: Rigid body Dynamics and Small Oscillations (20 Hours)

Motion of a rigid body, Euler angles, finite and infinitesimal rotations- Angular momentum and Moment of inertia-principal axes-principal moments of inertia- Euler's equations of motion for a rigid body- Small oscillations: simple harmonic, forced, damped and anharmonic oscillations- one dimensional oscillator-two coupled oscillators-normal co-ordinators and normal modes-general theory of small oscillations-secular equation and eigen value equation-Eigen value calculations of a linear triatomic molecules-

Module III: Hamiltonian Formulation and Phase Plane Analysis (16 Hours)

Canonical momentum-Cyclic co ordinates-Hamiltonian function and Jacobi's integral-Hamilton's canonical equations of motion.

Phase plane analysis: Linear stability analysis - The stability matrix – Classification of fixed points – A few examples of fixed point analysis – phase curve of simple harmonic oscillator and damped oscillator – phase portrait of the pendulum.

Module IV: Transformations of Phase Space and Hamilton- Jacobi Theory (20 Hours)

Canonical transformation – methods of constructing canonical transformations – different cases – generating function– harmonic oscillator– examples – conditions for canonical transformation. Poisson Brackets – properties – equations of motion in Poisson bracket form – angular momentum Poisson brackets - Hamilton-Jacobi equation – free fall under gravity – harmonic oscillator problem - Hamilton's principal function and characteristic function- physical significance with harmonic oscillator as an example. Action and Angle variables in systems of one degree of freedom-Harmonic oscillator. Hamilton-Jacobi equation as the short wavelength limit of Schrodinger equation.

Reference

1. J C Upadhyay, Classical Mechanics, Himalaya Publishing House, 2013.
2. Steven H Strogatz, Nonlinear dynamics and chaos, CRC Press, Taylor and Francis Group, 2013.
3. G. Aruldhas, Classical Mechanics, Prentice Hall, 2009
4. H. Goldstein, C. Poole and J. Safko, Classical Mechanics, 3 rd Ed. Addison Wesley, 2005.
5. L. D. Landau and E. M. Lifshitz, Mechanics, Vol. 1 of course of Theoretical Physics, Pergamon Press, 2000.
6. S.T. Thronton and J.B.Marion, Classical Mechanics of Particles and Systems, 5th Edition, Brook/Cole Publishing co., 2004.
7. Michael Tabor, Chaos and Integrability in Nonlinear Dynamics, Wiley – Blackwell, 1989.
8. V.B. Bhatia, Classical Mechanics, Narosa Publishing House, New Delhi (1997).

BMPN103: ELECTRODYNAMICS, SPECIAL THEORY OF RELATIVITY AND NON-LINEAR OPTICS

Total Hours: 72

Credit: 4

Course Objective: To evaluate fields and forces in Electrodynamics and Magneto dynamics using basic scientific method. To provide concepts of relativistic electrodynamics and its applications in branches of Physical Sciences.

Course Outcome:

- Apply Maxwell's equations to a variety of problems involving time dependent phenomena.
- Solve problems involving the propagation and scattering of electromagnetic waves in a variety of media.
- Demonstrate an understanding of the characteristics of electromagnetic radiation.
- Have a good understanding of Special Relativity, especially as applied to electrodynamics.
- Analyze the radiation mechanisms of antennas
- Demonstrate knowledge of antennas in communication systems.
- Ability to discriminate between antennas on the basis of their electrical performance.

Module I: Basics of Electrodynamics and Electromagnetic Waves (18 Hours)

Magnetostatics-Lorentz force law-The Biot- Savart law-The divergence and curl of B-Comparison of Magnetostatics and electrostatics-Magnetic vector potential.-multipole expansion of the vector potential.

Maxwell's equations-electrodynamics before Maxwell-Maxwell's equations-magnetic charge-Maxwell's equations in Matter-boundary conditions-Conservation laws-Charge and energy-Continuity equation- Potential formulations, Gauge transformations, boundary conditions, Poyntings theorem-Conservation of Momentum-Maxwell's stress tensor-Angular momentum

Electromagnetic waves: The electromagnetic Waves in Vacuum-Electromagnetic waves in Matter-Reflection and transmission at Normal Incidence- Reflection and transmission at oblique Incidence- Absorption of electromagnetic waves in conductors-reflection at a conducting surface-Dispersion –frequency dependence of permittivity-Deduction of Cauchy's formula.

The electromagnetic Waves in Vacuum-Electromagnetic waves in Matter-Reflection and transmission at Normal Incidence- Reflection and transmission at oblique Incidence-Absorption of electromagnetic waves in conductors-reflection at a conducting surface-Dispersion –frequency dependence of permittivity-Deduction of Cauchy's formula.

Module II: Special Theory of Relativity and Relativistic Electrodynamics (18 Hours)

Matrix representation of Lorentz transformation – Minkowski space – structure of spacetime– Four vectors – Addition of velocities – Four velocity – Relativistic momentum and energy –Dynamics of relativistic particles – Lagrangian and Hamiltonian of relativistic charged particle – motion in a uniform static electric and magnetic fields. Minkowski forces, Magnetism as a relativistic phenomenon, Transformation of the field, Electromagnetic field tensor, Electrodynamics in tensor notation, Potential formulation of relativistic electrodynamics.

Module III: Electromagnetic Radiation (18 Hours)

Potential formulation in Electrodynamics-Scalar and vector potentials-Advanced and retarded potentials- Electric dipole radiation, Magnetic dipole radiation, Jefimenkos equations, Point charges, Lienard-Wiechert potential, Fields of a moving point charge, Power radiated by point charge-Larmour formula. Bremsstrahlung. Radiation reaction and its physical basis(Qualitative study only)

Module IV: Non Linear Optics (18 Hours)

Introduction – origin of non-linearity, Optical mixing, Second order Processes – Three wave mixing, Coupled wave equations, Manley-Rowe relations, Phase matching conditions, Second Harmonic generation, sum & difference frequency generation, Optical parametric amplification, frequency up-conversion, Light propagation in anisotropic media - The index ellipsoid, Pockels effect and Optical rectification. Third order Processes – Four wave mixing, Third harmonic generation, Kerr effect, Intensity dependent refractive index – self focusing, Optical phase conjugation, Non- linear Raman effects - hyper Raman effect - classical treatment - stimulated Raman effect - inverse Raman effect

Reference

1. Introduction to Electrodynamics-David J Griffiths, PHI
2. Antenna and wave guide propagation - K. D Prasad - Satyaprakashan.
3. Electromagnetic waves and radiating systems, E.C. Jordan & K.G. Balmain PHI, 1968
4. Electronic Communication Systems (5th edition) – George Kendy et.al – TMH
5. Antennas, J.D Kraus, Tata Mc-Graw Hill.

6. Classical Electrodynamics, J. D. Jackson, Wiley Eastern Ltd.
7. Electromagnetic fields, S. Sivanagaraju, C. Srinivasa Rao, New Age International.
8. Introduction to Classical electrodynamics, Y. K. Lim, World Scientific, 1986.
9. Non Linear Optics, Robert W. Boyd, Academic Press, New York, 1992.
10. Geoffrey New, Introduction to Nonlinear Optics, Cambridge University Press, 2011.
11. D L Mills, Nonlinear Optics Basic concepts, Springer-Verlag, 1991.
12. Electromagnetic Waves and Fields, V.V. Sarwate, Wiley Eastern Ltd, New Age International
13. The Feymann Lectures in Physics, Vol. 2, R.P. Feymann, R.B.Leighton & M. Sands.
14. Electronic Communication Systems, G. Kennedy & B. Davis, TMH.

BMPN104: ADVANCED ELECTRONICS

Total Hours: 72

Credit: 4

Course Objective: To develop an understanding of fundamentals of electronics in order to deepen the understanding of electronic devices that are part of the technologies that surround us.

Course Outcome:

The students will be able to:

- Develop competence in Combinational Logic Problem formulation and Logic Optimisation
- Develop design capability in the field of combinational logic using
- Develop competence in analysis of synchronous and asynchronous sequential circuits
- Develop design capability in synchronous and asynchronous sequential circuit
- Acquire knowledge on the fundamentals of analog integrated circuit
- Develop competence in linear and nonlinear Opamp circuit analysis
- Acquire knowledge on commonly used linear and non-linear applications of Opamps and Comparators
- Develop design competence in linear and non-linear Opamp Circuits
- Develop analysis and design competence on signal filtering and signal conversion

Module I: Operational Amplifiers and General Linear Applications (18 Hours)

Review of differential amplifiers - review of operational amplifiers - differential amplifier with one and two op amps - Frequency response of an op amp - voltage compensating networks

DC and AC amplifiers – AC amplifier with single supply voltage – Peaking amplifier – Summing , Scaling, averaging amplifiers – Instrumentation amplifier using transducer bridge – Differential input and differential output amplifier – Low voltage DC and AC voltmeter - Voltage to current converter with grounded load – Current to voltage converter – Very high input impedance circuit – integrator and differentiator.

Module II: Active Filters, Oscillators, Comparators and Converters (18 Hours)

Active filters – First order and second order low pass Butterworth filter - – First order and second order high pass Butterworth filter- wide and narrow band pass filter - wide and narrow band reject filter - All pass filter – Oscillators: Phase shift and Wien bridge oscillators – square, triangular and saw tooth wave generators- Voltage controlled oscillator.

Basic comparator - Zero crossing detector - Schmitt Trigger – Comparator characteristics - Limitations of op-amp as comparators - Voltage to frequency and frequency to voltage converters - D/A and A/D converters- Peak detector – Sample and Hold circuit.

Module III: Power Semiconductor Devices (18 Hours)

Power Electronics - power semiconductor devices - power diodes, SCR, Power MOSFET, Types of Power Electronic Circuits.

Thyristor commutation techniques - Natural commutation, forced commutation, self commutation, impulse commutation, external pulse commutation, load side commutation and line side commutation. Controlled Rectifiers - Principle of phase controlled converter operation, single phase semi converters, single phase full converters, single phase dual converters and single phase series converters. Static Switches - Single phase AC switches - three phase AC switches - three phase reversing switches - DC switches

Module IV: Inverters and Power Electronics for Photovoltaic Power systems (18 Hours)

Principle of operation - performance parameters - Single phase bridge inverter, Three phase inverters - 180^0 conduction and 120^o conduction, Voltage control of single phase inverters - single pulse width modulation, multiple pulse width modulation, sinusoidal pulse width modulation, modified pulse width modulation and phase displacement control.

Basics of photovoltaics. Types of PV power systems (qualitative ideas). Stand alone PV systems - battery charging, charge controllers- series charge regulator, shunt charge regulator and dc- dc converters, Inverters for stand alone PV systems

Reference

1. Electronic Instrumentation, H.S. Kalsi, TMH (1995)
2. Transducers and instrumentation, D.V.S. Murty, PHI (1995)
3. Op amps and linear Integrated Circuits, R.A. Gayakwad, PHI
4. Integrated Electronics, Millman J & Halkias CC, MGH
5. Power Electronics R.S Anandha Murthy, V Nattarasu, 2nd Edn. Pearson
6. Power Electronics Handbook - M.H Rashid. Academic Press (2001)
7. Power Electronics - Circuits - Devices and Applications, M.H. Rashid, PHI, 1988

SEMESTER II

BMPN205: MATHEMATICAL PHYSICS – II

Total Hours: 72

Credit: 4

Course Objective: To provide students the ability to hone the mathematical skills necessary to approach problems in advanced physics courses.

Course Outcome:

- Students will be able to Use Cauchy's integral theorem in Complex integration. Also know how to find Laurent series about isolated singularities and determine residues.
- Understand the nature of the Fourier series and how derivation of a Fourier series can be simplified.
- Students will gain a range of techniques employing the Laplace and Fourier Transforms in the solution of ordinary and partial differential equations.
- Geometrical perception of 3 dimensional space will be generalised to n-dimensional non-Euclidean space.
- Knowledge about construction of group, its properties and uses of group theory in Physical problems.

Module I: Functions of a Complex Variable (18 Hours)

Algebra of complex functions – Cauchy-Riemann conditions for analyticity – Milne-Thomson Method - Cauchy's integral theorem – Cauchy's integral formula – Taylor and Laurent expansion – poles and residues – residue theorem – evaluation of definite integrals.

Module II : Integral Transforms (18 Hours)

Fourier transform: Fourier sine and cosine transform, Properties Fourier transform

Laplace transforms – Properties of Laplace transforms- Applications- Finite wave train – Harmonic Oscillator- Evaluation of integrals

Inverse Laplace transforms: Properties and Problems, Solution to differential equations using Laplace transforms.

Module III: Group Theory (18 Hours)

Groups – group of transformations – multiplication table – conjugate elements and classes, subgroups – direct product groups – isomorphism and homomorphism – permutation groups – reducible and irreducible representation – Unitary representations – Schur's lemmas –

orthogonality theorem and interpretations – character of a representation – character tables and examples C2V, C3V, C4V – continuous groups – full rotation groups – rotation of functions and angular momentum – Lie groups and lie algebra – SU(2)-SO(3) homomorphism – irreducible representation of SU(2) group – SU(3) group.

Module IV: Tensors (18 Hours)

Definition of Tensors –Algebra of tensors - Kronecker delta - Associated Tensors, Metric Tensor, Contraction, Direct Product, Quotient Rule–Christoffel Symbols – Levi Cevita Symbol – Covariant Differentiation – Equation of Geodesic - Riemann-Christoffel tensor, Ricci tensor and Ricci scalar - Pseudo Tensors, Dual Tensors.

Reference

1. Mathematical Methods for Physicists, G.B. Arfken &H.J. Weber 4th Edition, Academic Press.
2. Mathematical Physics, H.K Dass & R. Verma, S.Chand & Co.
3. Mathematical Physics, B.D. Gupta, Vikas Pub.House, New Delhi
4. Mathematical Physics, B.S. Rajput, Y Prakash 9th Ed, Pragati Prakashan
5. Mathematical Methods in Classical and Quantum Physics, T. Dass & S.K. Sharma, Universities Press (2009)
6. Elements of Group Theory for Physicists, A.W. Joshy, New Age India.
7. Mathematical Physics, Sathyaprakash, Sultan Chand & Sons, New Delhi.
8. Group theory- Schaum’s series, Benjamin Baumslag & Bruce Chandler, MGH.
9. Tensor Calculus: Theory and problems, A. N. Srivastava, Universities Press.
10. A Students Guide to Vectors and Tensors, Daniel A. Fleisch, Cambridge university press.
11. Schaum’s outline of tensor calculus, David C. Kay, MGH.
12. Tensor calculus, U.C. De, Absos Ali Shake, Joydeep Sengupta, Narosa.

BMPN206: ELEMENTARY QUANTUM MECHANICS

Total Hours: 72

Credit: 4

Course Objective: To provide an understanding of the formalism and language of non-relativistic quantum mechanics. To understand the concepts of time-independent perturbation theory and their applications to physical situations.

Course outcome:

- To study the mathematical tools of quantum mechanics such as linear spaces, operator algebra, matrix mechanics, and eigenvalue problems in bra-ket notation.
- To understand the formal foundations of quantum mechanics and then study some exactly solvable systems.
- To get an idea about the origin of conservation laws and the consequences of addition of angular momenta.
- To study Quantum mechanical treatment of scattering in high and low energy limits.

Module I: The Formulation of Quantum Mechanics (18 Hours)

Vector spaces, the Hilbert space, dimensions and basis, Dirac notations, operators and properties- Hermitian adjoint, projection operators, commutator algebra, uncertainty relation between two operators, functions of operators, unitary operators, Eigenvalues and Eigenvectors of an operator, Infinitesimal and finite unitary transformations, representation in discrete bases, matrix representation of kets, bras, and operators, change of bases and unitary transformations, matrix representation of the Eigenvalue problem, representation in continuous bases, position representation, momentum representation, connecting the position and momentum representations, probability density, superposition principle, observables and operators, the uncertainty principle, expectation values, complete sets of commuting operators, measurement and the uncertainty relations.

Module II: Quantum Dynamics (18 Hours)

The equations of motion- Schrodinger, Heisenberg and the Interaction pictures of time development, Ehrenfest theorem, The linear harmonic oscillator in the Heisenberg picture, Hydrogen atom - polynomial method

Space-time symmetries, Space translation and conservation of linear momentum, Time translation and conservation of energy, Space rotation and conservation of angular momentum, Space inversion and time reversal.

Construction of symmetric and anti-symmetric wave functions, Slater determinant, Pauli exclusion principle, Bosons and Fermions, Spin wave functions for two electrons.

Module III: Theory of Angular Momentum (18 Hours)

Angular momentum operators, Fundamental commutation relations, Eigen values and eigen vectors of J^2 and J_z. Matrix representation of angular momentum operators, Pauli spin matrices, Orbital angular momentum, Spherical harmonics, Addition of angular momenta , Clebsh-Gordon coefficients, Simple examples $j_1=1, j_2=1/2$.

Module IV: The Theory of Scattering (18 Hours)

Scattering cross section and Scattering amplitude, Low energy scattering by a central potential : Partial wave analysis, phase shift and potential, scattering length, optical theorem, Scattering by a square well potential, The Ramsuoer Townsend effect, Scattering by hard sphere, resonance scattering, high energy scattering: The integral equation, Born approximation. Validity condition of Born approximation. Applications – Rutherford scattering, Yukawa potential.

Reference

1. Quantum Mechanics, Concepts and Applications, N. Zettily, John Wiley & Sons.
2. Quantum Mechanics, V. K. Thankappan, New Age International.
3. Modern Quantum Mechanics, J.J. Sakurai, Pearson Education.
4. Quantum Mechanics, G Aruldhas, PHI
5. A Modern Approach to Quantum Mechanics, John S. Townsend, Viva Books MGH
6. Basic Quantum Mechanics, A. Ghatak, Macmillan India.
7. Quantum Mechanics, Theory and Applications, Ajoy Ghatak and S Lokhnathan 5th edition, Macmillian India.
8. Quantum Mechanics B H Bransden and C J Joachain, Pearson Education
9. Principle of Quantum Mechanoics, R Shankar, Springer
10. Quantum Mechanics, an Introduction, W Greiner, Springer Verlag
11. Quantum Mechanics, E. Merzbacher, John Wiley
12. Introduction to Quantum Mechanics, D.J. Griffiths, Pearson.
13. Quantum Mechanics, L.I. Schiff, Tata McGraw Hill.
14. Quantum Physic Stephen Gasiorowics, John Wiley & Sons.
15. Quantum Mechanics V. Devanathan , Narosa
16. A Text Book of Quantum Mechanics, P.M. Mathews & K. Venkatesan, TMGH.
17. Fundamentals of Quantum Mechanics Y.R. Waghmare, S Chand & Co.

For further reference:

Quantum Physics Video Prof. V. Balakrishnan IIT Madras

BMPN207: STATISTICAL MECHANICS AND CHEMICAL THERMODYNAMICS

Total Hours: 72

Credit: 4

Course Objective: To have an appreciation for the modern aspects of equilibrium and non-equilibrium statistical physics. To describe the features and examples of Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics.

Course Outcome:

This course introduces statistical methods and chemical thermodynamics to prepare the student to understand the principles behind many macroscopic as well as microscopic phenomena in various fields of science.

Module I: Foundations of Statistical Mechanics (18 Hours)

Statistical basis of thermodynamics: macro states and micro states - connection between statistics and thermodynamics - Classical ideal gas - entropy of mixing and Gibbs paradox. Phase space of a classical system, Liouville's theorem. Ideas of probability-classical probability-statistical probability-axioms of probability theory-independent events-concepts of arrangements, permutations and combinations-statistics and distributions-binomial, Poisson, Gaussian distributions.

Module II: Statistical Description of System of Particles (18 Hours)

Microcanonical ensemble- partition function. Canonical ensemble - canonical partition function- Grand canonical ensemble – grand canonical partition Free energy and its connection with thermodynamic quantities. Calculation of thermodynamic properties from partition function. Simple applications of canonical distribution- paramagnetism, molecule in an ideal gas, Calculation of mean values in a canonical ensemble, Equipartition theorem and applications- mean kinetic energy of a molecule in a gas, Brownian motion, harmonic oscillator, specific heat of solids.

Module III:Chemical Thermodynamics and Surface Science (18 Hours)

Different aspects of equilibrium- mechanical, thermal and chemical equilibrium, equilibrium conditions and the Clausius-Clapeyron equation, phase transformations of a simple substance, first and second order phase transitions, Systems with variable number of particles-the condition for chemical equilibrium-electron and hole in semiconductors, approach to chemical equilibrium, the chemical potential- method of measuring and calculating chemical potential, external chemical potential. Adsorption and lattice binding- Langmuir monolayer adsorption isotherm.

Module IV: Advanced Statistical Mechanics (18 Hours)

Continuous phase transitions- Order parameter- Landau theory of continuous phase transition. Fluctuations- Brownian motion and Random walk problem-diffusion equation. Time dependence of fluctuations- power spectrum, correlation function. Detailed analysis of Brownian motion- fluctuation-dissipation theorem.

Reference

1. Statistical Mechanics—R K Pathria and Paul D Beale
2. Statistical Thermodynamics, New Age, M. C. Gupta
3. Fundamentals of Statistical Mechnaics, New Age, B B Laud
4. Fundamentals of statistical and thermal physics, F Reif, Levant books
5. Statistical Mechanics, New Age Publishers, B K Agarwal and Melvin Eisner
6. Statistical Mechanics, John Wiley & Sons - K. Huang
7. Equilibrium statistical physics M. Plischke and B. Bergesen
8. Heat and Thermodynamics, McGraw Hill, A K Chattopadhyay
9. Statistical mechanics and properties of matter, Ellis Horwood Ltd, E S R Gopal
10. Introductory statistical mechanics, Oxford Science Publications, Robert Bowley
11. Statistical Physics, Pergamon Press, Landau and Lifshitz

BMPN208: SOLID STATE PHYSICS

Total Hours: 72

Credit: 4

Course Objective: To provide extended knowledge of principles and techniques of solid state physics. To provide an understanding of structure, thermal and electrical properties of matter.

Course Outcome:

After finishing the course the student should be able to;

- relate crystal structure and degree of ordering to atom binding and packing
- classify condensed matter upon its degree of order, with emphasis on scattering experiments
- explain the thermal properties in solids in particular heat capacity
- classify condensed matter upon its electrical and transport and magnetic properties
- apply the obtained concepts to challenges in condensed matter physics.

Module I: Elements of Crystal Structure and Free Electron Theory of Metals (18Hours)

X-ray diffraction- Braggs equation, Laue's equation and their equivalence, Ewald construction, reciprocal lattice, reciprocal lattice to SC, BCC, and FCC- properties of reciprocal lattice, X-ray diffraction method by rotation / oscillation method)

Free Electron Theory of Metals: Electrons moving in a three dimensional potential well - density of states - Fermi-Dirac statistics - Electronic specific heat - electrical conductivity of metals - relaxation time and mean free path - electrical conductivity and Ohm’s law - Widemann-Franz-Lorentz law - electrical resistivity of metals- Hall effect, Thermionic emission, Failure of free electron theory.

Module II: Band Theory of Metals and Semiconductors (18 Hours)

Bloch theorem - Kronig-Penney model - Brillouin zone construction of Brillouin zone in one and two dimensions – extended, reduced and periodic zone scheme of Brillouin zone, Number state in the bands

Band theory of semiconductors: Generation and recombination - minority carrier life-time - mobility of current carriers - drift and diffusion - general study of excess carrier movement-diffusion length.Free carrier concentration in semiconductors - Fermi level and carrier concentration in semiconductors - mobility of charge carriers - effect of temperature on mobility - electrical conductivity of semiconductors – Hall effect in semiconductors -

junction properties- metal-metal, metal semiconductor and semiconductor-semiconductor junctions.

Module III : Lattice Dynamics and Superconductivity (18 Hours)

Vibrations of crystals with diatomic lattice – quantization of elastic waves – phonon momentum. Anharmonicity and thermal expansion - specific heat of a solid – Einstein model - density of states - Debye model – thermal conductivity of solids - thermal conductivity due to electrons and phonons - thermal resistance of solids.

Superconductivity: Thermodynamics and electrodynamics of superconductors- London Equations- flux quantization-single particle tunnelling- Josephson superconductor tunnelling-macroscopic quantum interference-BCS Theory of Superconductivity

Module IV: Magnetic and Dielectric Properties of Solids (18 Hours)

Review of basic terms and relations in magnetism-Classical theory of pararmagnetism-paramagnetic susceptibility of solid substances-Quantum theory of paramagnetism-Ferromagnetism-origin of ferromagnetism-Quantum theory of ferromagnetism-Weiss Molecular field-Curie-Weiss law-spontaneous magnetisation-internal field and exchange interaction-magnetisation curve-saturation magnetisation-domain model (refer chapter 7 of text .Magnetic materials Fundamentals and applications by Nicola A Spalidin)

Dielectric properties of solids: Polarisation-dielectrics-Linear Dielectrics- Ferro-electric materials-Dipolar theory of ferroelectric materials-classification of ferroelectric materials-antiferroelectricity, Introduction to metamaterials.

Reference

1. Introduction to Solid State Physics, C. Kittel, 3rd Edn. Wiley India.
2. Solid State Physics: Structure and Properties of Materials, M. A. Wahab, Narosa 2nd Edn.
3. Solid State Physics, S.O. Pillai, New Age International 6th Edn.
4. Solid State Physics, N.W. Ashcroft & N.D. Mermin, Cengage
5. Elementary Solid State Physics, M. Ali Omar, Pearson
6. Solid State Physics, A.J. Dekker, Macmillan & Co Ltd. (1967)
7. Introduction to Solids- Azaroff. V –TM
8. Magnetic materials: Fundamentals and applications Nicola A Spaldin Cambridge university Press 2nd edition
9. Metamaterials Transformation optics and cloaks invisibility-John Pendry.

10. Metamaterials Characteristics, Process and Applications, Kaushal Gangwar, Paras and Dr. RPS Ganwar.

SEMESTER I AND II

PRACTICAL

BMPN2P01: GENERAL PHYSICS PRACTICALS

Total Hours: 162

Credit: 3

(Minimum of 12 Experiments with Error analysis of the experiment is to be done)

1. Y, n, σ Cornu's method (a) Elliptical fringes and (b) Hyperbolic fringes.
2. Absorption spectrum –$KMnO_4$ solution / Iodine vapour – telescope and scale arrangement – Hartmann's formula or photographic method
3. Hall Effect (a) carrier concentration (b) Mobility & (c) Hall coefficient.
4. Resistivity of semiconductor specimen–Four Probe Method.
5. Band gap energy measurement of silicon.
6. Magnetic Susceptibility-Guoy's method / Quincke's method.
7. Michelson Interferometer - λ and dλ / thickness of mica.
8. B - H Curve-Hysteresis.
9. Oscillating Disc-Viscosity of a liquid.
10. Dielectric constant of a non-polar liquid.
11. Dipole moment of an organic molecule (acetone).
12. Young's modulus of steel using the flexural vibrations of a bar.
13. Verification of Stefan's law and determination of Stefan's constant of radiation
14. Temperature dependence of a ceramic capacitor and verification of Curie-Wiess law
15. Zeemann effect setup – measurement of Bohr magnetron
16. Photoelectric effect – determination of Plank's constant using excel or origin.
17. Magneto-optic effect (Faraday effect)- rotation of plane of polarization as a function of magnetic flux density.
18. Linear electro-optic effect (Pockels effect) – half wave voltage and variation of intensity with electric field.
19. Silicon diode as a temperature sensor.
20. Electrical and thermal conductivity of copper and determination of Lorentz number.

[Few more experiments of equal standard can be added.]

BMPN2P02: ELECTRONICS PRACTICALS

Total Hours: 162

Credit: 3

(Minimum of 12 experiments should be done, with not less than 5 from each section)

Section –A

1. R C Coupled CE amplifier - Two stages with feedback – Frequency response and voltage gain.
2. Differential amplifiers using transistors and constant current source -Frequency response, CMRR.
3. Push-pull amplifier using complementary - symmetry transistors power gain and frequency response.
4. R F amplifier - frequency response & band width - Effect of damping.
5. Voltage controlled oscillator using transistors.
6. Voltage controlled oscillator using IC 555
7. R F Oscillator - above 1 MHz frequency measurement.
8. Differential amplifier - using op-amp.
9. Active filters – low pass and high pass-first and second order frequency response and roll off rate.
10. Band pass filter using single op-amp-frequency response and bandwidth.
11. Wein-bridge Oscillator – using op-amp with amplitude stabilization.
12. Op-amp-measurement of parameters such as open loop gain – offset voltage – open loop response.
13. Crystal Oscillator
14. RC phase shift oscillator
15. AM generation and demodulation
16. Current to voltage and voltage to current converter (IC 741)
17. Temperature measurement using ADC and microprocessor.
18. Op-amp-triangular wave generator with specified amplitude.
19. Ardunio based - stepper motor control.
20. Ardunio based - measurement of analog voltage.
21. Interfacing various sensors using Ardunio
22. Interfacing Analog to digital convertor ADC 0808.
23. Measurement of Light intensity using 8085 uP kit and ADC 0808.

Section –B: (Circuit Simulation)

1. Design and simulate a single stage RC coupled amplifier with feedback. Study the frequency response
2. Design and simulate a two stage RC coupled amplifier with feedback.Study the frequency response.
3. Design and simulate an RC phase shift oscillator using BJT and observe the sinusoidal output waveform.
4. Design and simulate the first order and second order low pass Butterworth filter for a cut off frequency of 1KHz. Obtain the frequency response curve and determine the roll off rate.
5. Design and simulate a differential amplifier using transistors with constant current source. Study its frequency response. Also determine its CMRR.
6. Design and simulate a differentiator and integrator using Op-amp. Obtain the output waveform for an input square wave.

[Few more experiments of equal standard can be added.]

SEMESTER III

BMPN309: ADVANCED QUANTUM MECHANICS

Total Hours: 72

Credit: 4

Course Objective: This is an advanced level course in Quantum mechanics, which objects to teach about various approximation methods in physics to calculate the approximate values of energy for various systems.

Course Outcome:

After having taken this course the student will have acquired the following skills:

- A working knowledge of non-relativistic and relativistic quantum mechanics including time-dependent perturbation theory, scattering theory, relativistic wave equations, and second quantization.
- The ability to understand concepts and to perform calculations of scattering of particles.
- The ability to critically understand and evaluate modern research utilizing quantum theory in condensed matter, nuclear and particle physics.

Module I: Approximation Methods for Time-Independent Problems (18 Hours)

Time-independent perturbation theory, Non-degenerate and degenerate cases, Anharmonic oscillator, Stark and Zeeman effects in hydrogen.

The WKB approximation, connection formulae, validity of the approximation, barrier tunneling, application to decay - Bound states, Penetration of a potential barrier.

Variational method: The variational equation, ground state and excited states, the variation method for bound states, application to ground state of the hydrogen and Helium atoms.

Module II: Time Dependent Perturbation Theory (16 Hours)

Time dependent perturbation theory Transition probability, constant perturbation, Transition to continuum, Harmonic perturbation, Interaction of an atom with the electromagnetic field, Stimulated absorption and emission-Einstein's A and B coefficients The electric dipole approximation, The Born approximation and scattering amplitude.

Module III: Relativistic Quantum Mechanics (24 Hours)

First order wave equations-The Dirac equation, Dirac matrices, Solution of the free-particle Dirac equation, , Equation of continuity - Non-realistic limit-The Dirac equation with potentials, Spin of the electron, Spin-orbit coupling, Lorentz Covariance of the Dirac equation- Charge conjugation for the Dirac equation- Hole theory, the Weyl equation

The second order wave equation. The Klein-Gordon equation, Charge and current densities, The Wave equation for the photon,.

Module IV: Quantization of fields (14 Hours)

The principles of canonical quantization of fields, Lagrangian field theory, Classical field equations, Hamiltonian formalism, nonrelativistic fields-system of Fermions-system of Bosons, quantization of Electromagnetic field-Coulomb's gauge.

Reference

1. V.K. Thankappan: "Quantum Mechanics" (Wiley Eastern)
2. N.Zittili, , "Quantum Mechanics – Concepts and applications" (John Wiley & Sons, 2004)
3. P.M Mathews and Venkatesan., "P.M.Mathews and K.Venkitesan,A Text Book of Quantum Mechanics,Tata Mc Graw Hill (2010)
4. J.D. Bjorken and D. Drell : "Ralativistic Quantum Fields" (McGraw Hill 1998)
5. L.I. Schiff : Quantum Mechanics" (McGraw Hill)
6. J.J. Sakurai : "Advanced Quantum Mechanics " (Addison Wesley)
7. Stephen Gasiorowicz : "Quantum Physics"
8. G.Aruldas,QuantumMechanics,SecondEdition,PHI learning Pvt Ltd (2009)
9. S.Devanarayanan,*QuanrtumMechanics*,Sci Tech Publications (India) Pvt Ltd (2005)
10. D.J.Griffiths,*Indroducion to Quanum Mechanics*, Second Edition,Pearson Education Inc (2005)
11. A.Ghatak and S.Lokanathan ,QuantumMechancis Theory and Applications,Kluwer Academic Publishers (2004).
12. L.H.Ryder,Quantum Field TheorySecondEdition,Cambridge University Presss (1996)
13. Steven Weinberg,Quantum Theory of Fields(in Three Volumes), Cambridge University Presss (2002)
14. A Modern Approach to Quantum Mechanics, John S. Townsend, Viva Books MGH

BMPN310: NUMERICAL METHODS IN PHYSICS

Total Hours: 72

Credit: 4

Course Objective: The aim is to teach various computational methods such as interpolation, numerical solutions for integration, differentiation, ordinary and partial differential equations. Further, course also aims for imparting knowledge and training in MathLab software.

Course outcome

- Introduces various computational methods for solving problems in physics
- Teaches programming tactics, numerical methods and programming using Matlab.
- learn the basics of scientific numerical simulation and modeling using Matlab.
- learn how to incorporate modern computation and visualization into the scientific problem-solving paradigm

Module I: Interpolation (16 Hours)

Interpolation and Curve fitting- Finite differences(Forward differences, Backward differences, Central differences) - Detection of errors by use of difference tables-Differences of a polynomial – Newton's formulae for interpolation - Central difference interpolation formulae (Gauss central difference formulae, Stirlings formulae) - Interpolation with unevenly spaced points (Lagrange's interpolation formulae) Least squares curve fitting procedures (Fitting a straight line, parabola and exponential)

Module II: Integration and differentiation (16 Hours)

Numerical differentiation and integration - Numerical differentiation – Errors in Numerical differentiation - Trapezoidal rule-Simpson's 1/3 rule - Simpson's 3/8 rule - Romberg Integration- Monte Carlo evaluation of integrals - Double Integration -Newton-cotes integration formulae.

Module III: Ordinary and partial differential equations (20 Hours)

Numerical Solutions of partial differential equations - Finite difference approximations to derivatives - Laplace equation-Jacobi's method – Gauss Seidal method - Successive over relaxation - The ADI method – Parabolic equations

Numerical solution of ordinary differential equations - Solution by Taylor's series - Picards method of successive approximations - Euler's method - Runge-Kutta methods-Predictor-Corrector methods; Adom Moulton method and Milne's method.

Module IV: Introduction to MATLAB (20 Hours)

Matlab programming: Matrices and vectors, Scripts and functions, Linear Algebra, Curve fitting and interpolation, data analysis, integration and differentiation, Fourier analysis Ordinary differential equations, Graphics

Reference

1. Introductory Methods of Numerical Analysis-fifth edition, S.S. Sastry, PHI Learning private Limited
2. Numerical Methods for Scientists and Engineers-third edition, K. Sankara Rao, PHI Learning private Limited
3. Getting started with MATLAB 7-A quick introduction for scientists and Engineers
4. Mastering MATLAB 7, Duane Hanselma, Bruce Littlefield, Pearson Education
5. Computer oriented numerical methods, V. Rajaraman, PHI Learning private Limited
6. An Introduction to Computational Physics, Tao Pang, CUP
7. Numerical Recipes in C++,W.H. Press, Saul A. Teukolsky, CUP
8. Numerical Methods, Balaguruswami, Tata McGraw Hill, 2009.

BMPN311: RENEWABLE ENERGY SOURCES

Total Hours: 72

Credit: 4

Course Objective: This course aims at the development of detailed knowledge about various renewable energy resources available in India and also about new source of energy: hydrogen. Further, course offers idea about the latest energy storage technology available in the world.

Course outcome

- Understanding about the need of Wind Energy and the various components used in energy generation and its classifications.
- Understand the concept of Biomass energy resources and their classification, types of biogas Plants
- Acquire the knowledge of wave power, tidal power, ocean thermal, geothermal principles and applications.
- Understand the various types of fuel cell and hydrogen production ,storage and transportation systems

Module I: Wind and Hydroelectricity (18 Hours)

Basics of Wind Energy Conversion- Power available in the wind- Wind Turbine power -Types of rotors: Horizontal and Vertical axis wind turbine- Aerodynamics of wind turbine: Airfoil, lift and drag characteristics-Axial momentum theory-Measurement of wind-wind direction- Power curve of wind turbine- Wind electric generators- performance of wind machines – variable speed constant frequency scheme- variable speed variable frequency scheme.

Hydroelectricity: Elements of hydro-electric Power plant -Classification of hydroelectric plants based on head, nature of load and quantity of water available- Estimation of power -Types of turbine-impulse and reaction turbines –Francis, Propeller, Kaplan turbine

Module II: Ocean Energy (18 Hours)

Tidal Power-Tidal Phenomenon –Estimation of Energy potential for a Tidal power project -components of tidal power plant-types of tidal power plant, Single basin and Double basin arrangement. Wave Energy- Energy and power from waves-wave energy conversion machines, Float wave power machine, high level reservoir, Dolphin type, hydraulic accumulator, oscillating duck, oscillating water column surge device. Ocean Thermal Energy

Conversion (OTEC)-Introduction –working principle- types of OTEC plants, Closed cycle, Open cycle, Modified open cycle OTEC plant

Module III: Geothermal and Biomass Energy (18 Hours)

Geothermal -Introduction-Structure of earth interior-energy of earth- Geothermal Resources, Vapor dominated system, liquid dominated system.

Biomass-Introduction-Resources-Biomass conversion processes-Anaerobic digestion system-components of Biogas plant-classification of Biogas plant, Continuous type, Batch type, Floating drum, Fixed dome -Biomass Gasification-classification of Gasifiers, Fixed bed and Fluidised bed gasifiers

Module IV: Fuel Cells and Hydrogen (18 Hours)

Fuel cell: Introduction-Components and working of a Fuel Cell , Classification of Fuel Cells based on Electrolyte-AFC,PAFC,PEMFC,MCFC,SOFC- Advantages, Disadvantages and application of Fuel Cells, Performance analysis of Fuel cell-Fuel cell power plant.

Hydrogen Energy, Hydrogen production (Electrolysis method, Thermo-chemical methods, Fossil fuel methods, solar energy methods), Hydrogen storage, Hydrogen transportation, Utilization of Hydrogen Gas, Hydrogen technology development.

Reference

1. Non conventional energy sources and utilization, R K Rajput, S. Chand
2. Wind Energy: Fundamentals, Resource Analysis and Economics; Mathew Sathyajith; 2006; Springer
3. Solar Energy Principles of Thermal Collection and Storage, S.P. Sukhatme,2nd Ed. TMH
4. Solar Engineering of Thermal Process, J.A. Duffie & W. A Beckman, 2nd Ed. John Wiley & sons.
5. Solar energy, H. P. Garg and J Prakashi, TMH 1997
6. Solar Energy Utilization, G D Rai, Khanna Publishers, 1997.
7. Renewable Energy Source and Conversion Technology, N.K Bansal, M. Kleemanm & M. Melss, TMH.
8. Renewable Eneregy, Godfrey Boyle, Oxford Univ. Press, 1996
9. Renewable Energy 2000, G.T. Wrixon, A.M.E. Rooney & W. Palz, Springer Verlag
10. Solar Power Plants, C.J. Winter, R.L. Sizmann & L.L Vant-Hull, Springer Verlag.
11. Non Conventional Energy Sources – G. D. Rai

BMPN312: MICROPROCESSORS AND MICROCONTROLLERS

Total Hours: 72

Credit: 4

Course Objective: This course is expected to provide knowledge of Micro Processor and Interfacing Devices.

Course outcome

- Assess and solve basic binary math operations using the microprocessor and explain the microprocessor's and Microcontroller's internal architecture and its operation
- Apply knowledge and demonstrate programming proficiency using the various addressing modes and data transfer instructions of the target microprocessor and microcontroller.
- Design electrical circuitry to the Microprocessor I/O ports in order to interface the processor to external devices.
- Evaluate assembly language programs and download the machine code that will provide solutions real-world control problems.

Module I: Transducers, Peripheral Devices and Data Transfer Schemes (18 Hours)

Classifications of transducers –light sensors (photoconductive cell, semiconductor photodiode) –temperature sensors (Thermocouple and Thermistor) Force sensors –strain gauges. Basics of programmable I/O-Architecture and programming of 8255PPI-serial port controller-standard I/O and Memory mapped I/O. ADC 0808 internal architecture and pin diagram –sample and hold IC (LF398). Clock for A/D convertor. Internal architecture of DAC 0808. Static RAM (6264)-logic block diagram & pin configuration. Data transfer schemes: classifications of data transfer schemes-programmed data transfer-synchronous –asynchronous transfer –interrupt driven data transfer-single interrupt level. software polling –hardware polling.

Module II: Microprocessor 8085 and Interfacing Peripheral Devices (18 Hours)

Terms used in microprocessor literature-Basic functional blocks of a microprocessor-organisation of a microcomputer-concept of multiplexing in microprocessor. intel 8085-archtecture and pins –instruction set-Example programs - Demultiplexing of address/data lines in 8085.8085 Memory organisation in a 8 bit microprocessor system-sketches highlighting implementation of 16 KB RAM- and 32KB RAM and its Address mapping . Interfacing 8255 with 8085 -Interfacing circuit and control software for interfacing ADC/DAC with 8085.

Module III: Introduction to Python Programming (16 Hours)

Python programming basics –strings-numbers and operators-variables-functions, Classes and objects-organizing programs-files and directories-other features of Python language.

Module IV: Microcontrollers (Intel 8051) and embedded programming (20 Hours)

Introduction to microcontrollers-comparison of microprocessors and microcontrollers-Architecture of 8051 microcontroller- programming model -Port structure -–introduction to Assembly level programming- addressing modes-Familiarisation of Edsim assembler and example programs. Introduction to arduino board. Interfacing procedure for arduino board to computer- C language basics -developing simple sketches for interfacing various sensors to the boards.

Reference:

1. Electronic Instrumentation, H. S. Kalsi TMH (1995)
2. Microprocessors and Microcontrollers, A Nagoor Kani, 2nd Ed. TMH, New Delhi
3. Fundamentals of Microprocessor and Microcomputers, B. Ram, Dhanpat Rai Publications
4. Introduction to Microprocessors Aditya P Mathur, 3rd edition, T M H, India
5. The Microcontroller and Embedded systems Using Assembly and C, Muhammad Ali Mazidi, Person, 2nd ed.
6. The 8051 microcontroller Kenneth J Ayala
7. Advanced microprocessors and peripherals, Architecture, Programming and Interfacing A K Ray T M H
8. www.ardunio.cc
9. www.edsim51.com
10. Beginning python by Peter Norton (Chapter 1 to 9) Wiley Publishing

SEMESTER IV

BMPN413: ATOMIC AND MOLECULAR PHYSICS

Total Hours: 72

Credit: 4

Course Objective: To provide an understanding of the fundamental aspects of atomic and molecular physics. To study spectroscopy of the multi-electron atoms and diatomic molecules.

Course Outcome

- Understands the nature and behaviour of interactions between matter and energy at both the atomic and molecular level.
- Study the basic principles of the different spectroscopic techniques, methods and the interpretation the spectrum.

Module I: Atomic Spectra (18 Hours)

The hydrogen atom and the three quantum numbers *n*, *l* and *ml.* - electron spin - spectroscopic terms. Spin-orbit interaction, derivation of spin-orbit interaction energy, fine structure in sodium atom, selection rules. Lande gfactor, normal and anomalous Zeeman effects, Paschen–Back effect and Stark effect in one electron system. Hund's rule, Lande interval rule. Hyperfine structure and width of spectral lines. (qualitative ideas only).

Module II: Microwave and Infra Red Spectroscopy (18 Hours)

Microwave Spectroscopy: Rotational spectra of diatomic molecules - intensity of spectral lines - effect of isotopic substitution. Non–rigid rotor - rotational spectra of polyatomic molecules - linear and symmetric top - Interpretation of rotational spectra.

IR Spectroscopy: Vibrating diatomic molecule as anharmonic oscillator, diatomic vibrating rotor – break down of Born-Oppenheimer approximation - vibrations of polyatomic molecules - overtone and combination frequencies - influence of rotation on the spectra of polyatomic molecules - linear and symmetric top - analysis by IR technique - Fourier transform IR spectroscopy.

Module III: Raman and Electronic Spectroscopy (18 Hours)

Raman Spectroscopy: Pure rotational Raman spectra - linear and symmetric top molecules - vibrational Raman spectra – Raman activity of vibrations - mutual exclusion principle - rotational fine structure - structure determination from Raman and IR spectroscopy. Electronic Spectroscopy: Electronic spectra of diatomic molecules - progressions and sequences - intensity of spectral lines. Franck – Condon principle - dissociation energy and dissociation products - Rotational fine structure of electronic-vibrational transition - Fortrat parabola - Predissociation.

Module IV: Spin Resonance Spectroscopy (18 Hours)

NMR: Quantum mechanical and classical descriptions - Bloch equations - relaxation processes - chemical shift - CW spectrometer - applications of NMR.

ESR: Theory of ESR - thermal equilibrium and relaxation - g- factor - hyperfine structure - applications.

Mossbauer spectroscopy: Mossbauer effect - recoilless emission and absorption - hyperfine interactions – chemical isomer shift - magnetic hyperfine and electronic quadrupole interactions - applications.

Reference

1. Introduction of Atomic Spectra, H.E. White, Mc Graw Hill
2. Spectroscopy (Vol. 1, Vol. 2 & 3), B.P. Straughan & S. Walker, John Wiley &Sons, Science paperbacks 1976
3. Raman Spectroscopy, D.A. Long, Mc Graw Hill international, 1977
4. Introduction to Molecular Spectroscopy, G.M. Barrow, Mc Graw Hill
5. Molecular Spectra and Molecular Structure, Vol. 1, 2 & 3. G. Herzberg, Van Nostard, London.
6. Elements of Spectroscopy, Gupta, Kumar & Sharma, Pragathi Prakshan
7. The Infra Red Spectra of Complex Molecules, L.J. Bellamy, Chapman & Hall. Vol. 1 & 2.
8. Laser Spectroscopy techniques and applications, E.R. Menzel, CRC Press, India
9. Fundamentals of molecular spectroscopy, C.N. Banwell, Tata McGraw Hill
10. Molecular structure and spectroscopy, G. Aruldhas, PHI Learning Pvt. Ltd.
11. Lasers and Non-Linear Optics, B.B Laud, Wiley Eastern
12. Mossbauer Spectroscopy – principles and applications, Philip Gutlich.
13. Introduction to Solid State Physics, C. Kittel, Wiley Eastern

BMPN414: ADVANCED NUCLEAR PHYSICS

Total Hours: 72

Credit: 4

Course Objective: The students will have an understanding of the structure of the nucleus, radioactive decay, nuclear reactions and the interaction of nuclear radiation with matter; and develop an insight into the building block of matter along with the fundamental interactions of nature.

Course Outcome:

On satisfying the requirements of this course, students will have the knowledge and skills to:

- Analyse production and decay reactions for fundamental particles, applying conservation principles to determine the type of reaction taking place and the possible outcomes
- Describe the role of colour in the strong force, and appreciate why going from strong interactions between quarks to nuclear structure is a currently unsolved problem
- Describe the role of spin-orbit coupling in the shell structure of atomic nuclei, and predict the properties of nuclear ground and excited states based on the shell model
- Apply quark mixing models to analyse weak interaction physics such as beta and kaon decay
- Read, understand and explain scholarly journal articles in nuclear and particle physics
- Make relevant measurements of energy and decay spectra using basic experimental facilities and apply Poisson statistics to evaluate the uncertainties in the data.

Module I: Nuclear Properties and Nuclear Force (18 Hours)

Nuclear radius, size, shape, mass and abundance of nuclides, binding energy, Semi-empirical mass formula, Nuclear angular momentum and parity, nuclear electromagnetic moments, nuclear excited states, deuteron- ground state, excited state, low energy neutron-proton scattering, scattering length Fermi scattering length, spin dependence of neutron- proton interaction, effective range theory, non central force, proton-proton and neutron-neutron interactions, exchange interaction and saturation of nuclear force, properties of the nuclear force, the exchange force model.

Module II: Nuclear decay and Radiation detections (18 Hours)

Review of alpha decay, Beta decay, Energy release in beta decay, Fermi theory of beta decay, Experimental tests of the Fermi theory, angular momentum and parity selection rules, Comparative half-lives, parity violation in beta decay. Energetics of gamma decay, Multipole radiations, classical electromagnetic radiation, transition to quantum mechanics, angular momentum and parity selection rules, internal conversion.

Interactions of radiation with matter, Gas filled counters, Scintillation detectors, semiconductor detectors, GM Counter, Counting statistics, Energy measurements, Measurements of nuclear lifetimes.

Module III: Nuclear Models and Applications (18 Hours)

Fermi gas model, Shell model, single particle states in nuclei, applications of shell model : Nuclear spin, nuclear magnetic moments, islands of isomerism, quadruple moments of nuclei, Collective model, vibrations in a permanently deformed nucleus, nuclear rotation

Fission -Induced fission – fissile materials, Fission chain reactions, Nuclear power reactors, Fusion-Coulomb barrier, stellar fusion, Fusion reactors, biomedical applications, Biological effects of radiation: radiation therapy, Medical imaging using radiation, Magnetic resonance imaging.

Module IV: Particle Physics (18 Hours)

Basic forces and classification of particles: The four basic forces, the force of gravity, the electromagnetic force, the week force and electroweak theory, the strong force. The Gell-Mann-Nishijima formula, Conservations laws: symmetries and Conservation laws, conservation of energy and mass, conservation of linear momentum, conservation of angular momentum, conservation of electric charge, conservation of baryon and lepton numbers, conservation of strangeness, conservation of isospin and its components. The CPT theorem, conservation of parity.

Quark model: The eightfold way, discovery of omega minus, the quark model, the confined quarks, experimental evidences for quark model, coloured quarks, quantum chromodynamics and gluons.

Reference

1. Introductory Nuclear Physics, Kenneth. S. Krane, Wiley, New York, (1987).

2. Nuclear and Particle Physics: An Introduction, Brian R. Martin, Wiley, England, (2006).

3. The particle Hunters, Yuval Ne'eman & Yoram kirsh, CUP, (1996).

4. Introduction to Nuclear Physics, H.A. Enge, Addison Wesley, London, (1975).

5. Nuclear Physics by R.R. Roy and B.P. Nigam, New Age International, New Delhi, (1983).

6. Atomic and Nuclear Physics, Ghoshal, Vol. 2, S. Chand & Company

7. Introduction to Elementary Particle, D.J. Griffiths, Harper and Row, NY,(1987)
8. The Ideas of Particle Physics, An Introduction for Scientists, G D Coughlan, J E Dodd and B M Geipaios, Cabridge University Press, Third Edition

BMPN415: SOLAR THERMAL COLLECTION AND STORAGE

Total Hours: 72

Credit: 4

Course Objective: The course objective is to provide student with basic knowledge about solar thermal concentrating systems. Also aims to provide knowledge about most common materials and their properties used in thermal applications.

Course Outcome:

Upon completion of this course, the students will be able to;

- Obtain a basic understanding of solar radiation measurements.
- Explain and apply the technical and physical principles of different thermal applications and storage of solar energy.
- Implement techniques of refrigeration and air conditioning by utilizing solar energy.

Module I: Solar Energy and Solar Radiation (18 Hours)

The Sun as the source of radiation-Solar constant-Spectral distribution of extraterrestrial radiation and its variation –Instruments for measuring solar radiation and sunshine – Solar radiation geometry – Solar radiation on titled surfaces.

Thermal Applications of Solar Energy - an Overview: Basic ideas about devices for thermal collection and storage – Thermal applications, water heating, space heating, space cooling and refrigeration, power generation, distillation, drying and cooking.

Selective Surfaces for Solar Energy Conversion: Use of selective surfaces on solar energy collectors – Anti-reflection coatings – Preparation techniques of selective coatings.

Module II: Flat Plate Collectors (18 Hours)

Performance analysis of fluid flat plate collectors – Transmissivity of cover system – Transmissivity absorptivity product – Overall loss coefficient and heat transfer correlation – Collector efficiency factor – Collector heat removal factor – Effects of various parameters on performance. Performance analysis of conventional air heater – Other types of air heaters.

Module III: Concentrating Collectors (18 Hours)

Parameters characterizing solar concentrators – Types of concentrating collectors – Cylindrical, parabolic concentrators – Performance analysis of cylindrical parabolic concentrators – Parametric study of cylindrical concentrating collectors – Compound parabolic collector (CPC), CPC geometry – Performance analysis – Central receiver collector (basic ideas).

Module IV: Solar Refrigeration and Air Conditioning (18 Hours)

Carnot refrigeration cycle – Principle of absorption cooling – Lithium bromide water absorption system – Aqua-ammonia absorption system -intermittent absorption refrigeration system – Vapour compression refrigeration – Desiccant cooling - solar pond – performance analysis of solar pond.

Thermal Energy Storage: Sensible heat storage – Latent heat storage – Thermo-chemical storage

Reference

1. Solar Energy - Principles of Thermal Collection and Storage, S.P. Sukhatme, 2nd Edn. TMH.
2. Solar Energy: Fundamentals and Applications; H. P. Garg & J. Prakash; 2000; Tata McGraw-Hill.
3. Solar Energy Utilization, G.D. Rai, Khanna Publ.
4. Solar Engineeering of thermal process, John A Duffie and W. A. Beckman, 2nd Edn John Wiley & Sons, INC.
5. Renewable Energy sources and Conversion technology, N K Bansal, M. Klemmann and M. Meliss, TMH.
6. Renewable Energy, Godfrey Boyle, Oxford Univ. Press.
7. Renewable energy 2000,G T Wrixon, A M E Roney and W. Palz, Springer Verlag.
8. Solar Power Plants, C. J. Winter, R. L. Sizmann and L L Vaithull, Springer Verlag.
9. Non-Conventional Energy Resources and Utilisation (Energy Engineering), Er. R K Rajput (S Chand & Co.)
10. Non- conventional energy resources D.S Chauhan and S.K Srivastava, New Age

SEMESTER III AND IV

PRACTICAL

BMPN4P03: COMPUTATIONAL PHYSICS PRACTICALS

Total Hours: 162

Credit: 3

[Programs are to be written in MATLAB for experiments in all sections. Method, algorithm and flow chart are to be developed. Total of 10 experiments are to be done with a minimum of 3 from each section]

Section A: (Numerical methods)

1. Write and execute a program for solving a system of linear equations using Gauss elimination method.
2. Write and execute a program to find the root of a non linear equation by bisection method.
3. Write and execute a program for the numerical integration of a function using trapezoidal method.
4. Write and execute a program for the numerical integration of a function using Simpson's 1/3 rule.
5. Write and execute a program to solve the given ordinary differential equation by using Euler method.
6. Write and execute a program to solve the given ordinary differential equation by using Runge-Kutta fourth order method.

Section B:

1. Write and execute a program to demonstrate the motion of a spherical body in a viscous medium. Study the effect on motion by changing the mass, size of the body and the medium. 8. Write and execute a program for the motion of a projectile in air. Study the motion for different angles of projection.
2. Write and execute a program to find the variation in position, velocity and acceleration of a damped harmonic oscillator. How do the oscillations go from the undamped to the critically damped and to over damped with variation in damping coefficient?

3. Write and execute a program to find the variation in acceleration, velocity, position and energy of a driven oscillator. Plot the position versus time graph for different driving conditions.
4. Write and execute a program to generate a pattern of standing waves. Run this program with different values of amplitude, wavelength and velocity.
5. Write and execute a program to analyze a series LCR circuit with an AC source. Verify the resonance condition.

Section C: Matlab Experiments

1. Retrieve a signal of specific amplitudes from an original corrupted signal using Fourier transforms.
2. Find out the solution of Laplace equation for finite sized capacitor using SOR method
3. Write a Matlab program to solve the equation of a non-linear pendulum and also to draw the velocity-time graph and phase plot for $\theta'' + \omega^2 \sin\theta = 0$ with initial condition $\theta(0) = 1$, $\theta'(0) = 0$.
4. Write a Matlab program to plot the output waveform of a full wave rectifier, its transfer characteristics and Lissajous pattern- 8 (horizontal and vertical)
5. Plot common signals encountered in signal processing such as unit impulse, unit step, ramp, exponential, sine wave, square wave, exponentially decaying sine wave and a unit circle using Matlab functions.
6. Write a Matlab Program for 3 body simulation of Jupiter, Earth and Sun.

Reference

1. Computational Physics, N Giordano and H Nakanishi, Pearson.

[Few more experiments of equal standard can be added.]

BMPN4P04: RENEWABLE ENERGY PRACTICALS

Total Hours: 162

Credit: 3

1. Solar Cell characteristics
2. Characteristics of PV Panel
3. Series and Parallel operation of PV Panels
4. Solar panel modeling and simulation
5. Efficiency of Solar Flat Plate Collectors
6. Improvement of Power Factor
7. Efficacy of Lamps
8. Study of Bio-gas plant (Lab Model)
9. Fluidized Bed Heat Transfer
10. Performance evaluation of a Single Basin Solar Still
11. Thermal testing of Box-type Solar Cooker
12. Determination of heat Loss Factor F'UL of linear Solar Absorbers using Indoor Test Facility
13. Determination of Time Constant of Solar Flat Plate Collector
14. Measurement of Solar Reflectance and Absorptance of surfaces
15. Performance Analysis of a Paraboloid Concentrator
16. Testing of a Solar Cabinet Drier
17. Determination of Optical Efficiency of a Seasonally Adjusted Linear Solar Concentrator

[Few more experiments of equal standard can be added.]

ELECTIVE COURSES

BMPN4E01: SOLAR PHOTOVOLTAICS

Total Hours: 72

Credit: 4

Course Objective: This course envisages learning of fundamental principles and generalizations or theories of photovoltaics.

Course Outcome :

- Knowledge about solar cell fundamentals ,generation of electricity from solar cell
- Thorough understanding of various solar cell parameters, its performance analysis
- Knowledge about different solar cell fabrication techniques
- Understanding about various PV system configurations like standalone ,grid connected and hybrid system
- Ability to design a stand-alone system according to our load requirements

Module I: Solar Cell Fundamentals (18 Hours)

Carrier motion in semiconductors- drift - motion due to electric fields - electric field and energy band bending - diffusion current - diffusion current density – drift and diffusion together – diffusion coefficient – generation of carriers – recombination of carriers – continuity of carrier concentrations.

P-N Junction Diode: An Introduction to Solar Cells - equilibrium condition – space charge region - energy band diagram – junction potential-width of depletion region – carrier movements and current densities – carrier concentration profile – p-n junction non - equilibrium condition - I-V relation (qualitative).

Module II: P-N junction (18 Hours)

P-N junction I-V relation: quantitative analysis - P-N junction under illumination – generation of photo voltage (PV) – light generated current – IV equation for solar cell – solar cell characteristics.

Design of Solar Cells: upper limits of solar cell parameters - short circuit current – open circuit voltage – fill factor – efficiency – losses in solar cell – model of solar cell – effect of series and shunt resistance, solar radiation and temperature on solar cell efficiency – solar cell design - design of high short circuit current – choice of junction depth and orientation – minimisation of optical losses and recombination – Design for high open circuit voltage –

design for high fill factor – base resistance – emitter resistance – analytical techniques – solar simulator: I-V measurement – quantum efficiency measurement – minority carrier life time and diffusion length measurement.

Module III: Production of Solar cells (18 Hours)

Solar Cell Technologies: Production of silicon (Si) – Silicon requirement –production of metallurgical grade Si - production of electronic grade Si - production of Si wafers – Si sheets – Si feedstock for solar cell industry – Solar grade production of Si wafers – Si usage in solar SPV - Si wafer based solar cell technology - development of commercial Si solar cells – high efficiency Si solar cells.

Thin Film Solar Cell Technologies: Generic advantages of thin film technologies – thin film deposition techniques – amorphous Si solar cell technology – thin film crystalline Si solar cell – microcrystalline Si thin film solar cell – thin film polycrystalline Si solar cell – thin film epitaxial Si solar cell.

Emerging solar cell Technologies-Organic solar cell, Dye sensitized solar cell, GaAs solar cell

Module IV: Solar Photovoltaic Applications (18 Hours)

Solar Photovoltaic (SPV) Modules – SPV from solar cells – series and parallel connections – mismatch in cell module – mismatch in series connection – hot spots in modules – bypass diode- mismatching parallel connection – design and structure of PV modules - number of solar cells wattage of modules – fabrication of modules – PV module power output – IV equation of PV modules – rating of PV modules - I-V and power curves of module – effect of solar irradiation and temperature - Balance of Solar PV Systems – electrochemical cells – factors affecting battery performance – batteries for SPV systems – Maximum Power Point Tracking (MPPT)-Constant voltage method-Hill climbing methods-Incremental conductance method-Photovoltaic System Design and Applications.- introduction to SPV systems – stand alone SPV system configurations – design methodology of SPV systems – wire sizing in SPV systems - price sizing of SPV systems - hybrid SPV systems - grid connected SPV systems - simple payback period – life cycle costing

Reference

1. Solar Photovoltaic: Fundamentals, Technologies and Applications, Chetan Singh Solanki, PHI, 2nd Edn
2. Practical Photovoltaics: Electricity from Solar Cells Practical Photovoltaics: Electricity from Solar Cells Richard J. Komp 3rd Edn. aatec Publishers, Michigan.

3. The Physics of Solar Cells (Properties of Semiconductor Materials), Jenny Nelson, Imperial College Press, London

BMPN4E02: NONLINEAR DYNAMICS AND INTRODUCTION TO CHAOS

Total Hours: 72

Credit: 4

Course Objective: Modern numerical and analytical methods will be introduced which allow to investigate dynamical systems used as mathematical models in science and engineering. Specific well known and important examples of applications from physics will serve as basis to explain the mathematical techniques.

Course Outcome:

On satisfying the requirements of this course;

- Students will be able to analyze the behaviour of dynamical systems expressed as either a discrete-time mapping or a continuous-time flow.
- Students will be able to apply the techniques of nonlinear dynamics to physical processes drawn from a variety of scientific and engineering disciplines.
- Students will be able to analyze changes to dynamical systems as system parameters are varied.
- Students will be able to independently research topics in nonlinear dynamics and synthesize this work into coherent written and oral presentations.

Module I: One Dimensional Flows and Bifurcations (18 Hours)

A dynamical view of the world. General introduction to linear and nonlinear equations - Flows on the line: Introduction - Geometric way of thinking - Fixed points and stability - Linear stability analysis - Existence and uniqueness theorem - Impossibility of oscillations: mechanical analogy (over damped systems) - Visualise the dynamics: potentials.

Bifurcations: Introduction - Saddle-node bifurcation - Transcritical bifurcation - Pitchfork bifurcation - Imperfect bifurcations and catastrophes: bead on a tilted wire.

Module II: Dynamics in Phase Plane (20 Hours)

Flows on the circle: Introduction - Examples and definitions - Uniform oscillator - Nonuniform oscillator - Overdamped pendulum. - Equivalent circuit and pendulum analog.

Linear Systems: Introduction - Examples and definitions - Classification of linear systems. Dynamical variables - Phase space - Phase trajectories and their properties - Fixed points and linearization - Stability. Stable and unstable manifolds. Lotka-Volterra model of competition - Conservative systems - Reversible systems. Phase plane analysis of pendulum - Cylindrical phase space - Damping effects. Index theory - Global information about the phase portrait.

Module III: Nonlinear Oscillations (16 Hours)

Limit cycles: Introduction - Liapunov functions - Poincare-Bendixson theorem - Lienard systems - Relaxation oscillations - Weakly nonlinear oscillators - Perturbation theory - Two timing - Method of averaging.

Saddle-node bifurcation - Transcritical bifurcation - Pitchfork bifurcation - hopf Bifurcation: Supercrittical and Subcrtitical. Coupled oscillators and quasiperiodicity - Poincare Maps.

Module IV: Chaotic Systems and Discrete Dynamical Systems (18 Hours)

The Lorenz System: Introduction - Elementary Properties of the Lorenz System - The Lorenz Attractor - A Model for the Lorenz Attractor - The Chaotic Attractor - Exploration: The Rössler Attractor.

Discrete Dynamical Systems - Introduction - 1D maps: Bernoulli, tent and logistic maps. Period-doubling route to chaos. Lyapunov exponents. The Cantor Middle-Thirds Set-Exploration: Cubic Chaos. Elementary ideas on turbulence. Strange attractors.

Reference

1. Nonlinear Dynamics and Chaos – STEVEN H. STROGATZ, Westview Press.
2. Differential Equations, Dynamical Systems and an Introduction to Chaos – MORRIS W. HIRSCH, Elsevier Academic Press.
3. Chaos and Integrability in Nonlinear dynamics – M. TABOR, John Wiley, 1989.
4. Chaos and Nonlinear Dynamics – R.C.HILBORN, Oxford University Press, 1994.

BMPN4E03: ASTROPHYSICS AND COSMOLOGY

Total Hours: 72

Credit: 4

Course Objective: We expect that after completion of the astrophysics major, students will be inspired to continue and share their interest in astronomical advances and discoveries throughout their lives and Have a solid grounding in the underlying principles and important conceptual models from core subject areas of astronomy and physics and demonstrate their ability to correctly draw logical conclusions from these principles and models, enabling them to make accurate quantitative predictions in astronomical contexts.

Course Outcome:

On satisfying the requirements of this course, students will have the knowledge and skills to:

- Apply rigorously the scientific method in the absence of controlled laboratory experiments
- Perform order of magnitude estimates and solve abstract Fermi problems
- List astrophysically relevant radiation mechanisms, and identify them based on their spectral properties
- Discuss the propagation of radiation in a medium
- Qualitatively discuss the structure of a star and its properties
- Discuss the properties of degenerate matter and the outcome of stellar evolution for stars of different mass
- List the components of the interstellar medium and discuss their interactions
- Describe the properties and evolution of different types of galaxies
- Describe the Big Bang cosmological model, and the evidence to support it
- Discuss the experimental support for the existence of dark matter and dark energy

Module I: Introduction (18 Hours)

Celestial Sphere: The altitude-Azimuth Coordiate system, Equatorial co-ordiate system; Celestial objects: Planets, Stars, Galaxies, Milkyway; Distance measurements: Parallalax method, Flux, Luminosity, Magnitude system: Absolute and apparent magnitude, distance modulus; Black body radiation, bolometric magnitude, filters, color index; Spectral lines (absorption and emission), spectral classification of stars, M-B velocity distribution, Boltzmann Equations, Saha's ionisation formula, Applications, H-R diagram.

Module II: Astronomical Instrumentation (16 Hours)

Telescopes: basic optics, Rayleigh Criterion, Seeing, Aberations, Brighness of an Image; Optical Telescopes: Refracting and Reflecting telescopes, Adaptive Optics, Radio Telescopes: Flux density, Interferometry; Atmospheric window in the electromagnetic spectrum: Infrared, UV, X-ray and Gamma ray astronomy.

Astronomical Photometry; Photometer, Light Detectors: Photomultiplier Tubes, PIN photodiodes; Charged Coupled Devices: Operation; Spectroscopy: Review of spectrographs, CCD spectrographs.

Module III: Stellar and Galaxy Physics (20 Hours)

Hydrostatic equilibrium: free fall, virial theorem for stars, equilibrium of a gas of non-relativistic ideal gas particles, virial temperature; Radiative energy transport: mean free path, sun's internal temperature; Equations of stellar structure; Equation of state; Opacity; Energy production: Nuclear reactions, p-p chain, reaction rate, power production in p-p chain, CNO cycle (brief discussion). Solutions of the equations of stellar structure: case of convection.

Structure of Milky-way, Components: the disk, the spheroid, centre, dark halo (from rotation curves), Galaxy demographies: Spiral and ellipticals, galaxy luminosity function. Groups and clusters of galaxies.

Module IV: Cosmology (18 Hours)

Metric tensor; Cosmological Principle; FRW metric: scale factor, Hubble's law, The big bang theory, Expanding universe, cosmological redshift; The Friedmann's equations (no derivation) and solutions; Comoving and Hubble horizon, angular diameter and luminosity distances; Evolution of isotropic fluid in expanding universe, Evolution radiation and matter. Epoch of matter radiation equality; Scale factor evolution (during inflation, radiation and matter dominated epochs); CMBR as an observational evidences for big bang (qualitative ideas only); Dark energy; Dark matter, Gravitational waves (Basic idea).

Reference

1. Basic Astrophysics - Dan Maoz.
2. Modern Cosmology - Scott Dodelson.
3. An Introduction to Modern Astrophysics - Bradley W. Caroll, Dale A. Ostlie, Addison-Wesley Publishing Company.
4. Astronomical Photometry - A Text and Handbook for the Advanced Amateur and Professional Astronomer, Arne A Henden and Ronald H Kaitchuck.
5. Handbook of CCD Astronomy - Second edition, STEVE B. HOWELL.

6. Structure formation in the universe- T. Padmanabhan.
7. Stellar Structure and Evolution - Second Edition, Rudolf Kippenhahn, Alfred Weigert, Achim Weiss.
8. Abhyankar K. D. - Astrophysics Stars and Galaxies, Universities Press.
9. Arnab Rai Choudhuri - Astrophysics for Physicists, Cambridge University.
10. Narlikar J. B. - Introduction to Cosmology, Cambridge University Press.

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