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SHIVAJI UNIVERSITY, KOLHAPUR - 416004, MAHARASHTRA

PHONE:EPABX-2609000, www.unishivaji.ac.in, bos@unishivaji.ac.in

शिवाजी विद्यापीठ, कोल्हापूर -४१६००४,महाराष्ट्र

दूरध्वनी-ईपीएबीएक्स -२६०९०००, अभ्यासमंडळे विभाग दुरध्वनी ०२३१—२६०९०९४
०२३१—२६०९४८७

SU/BOS/Science & Technology / 51 **Date: 08/01/2024**

To,

The Principal, **All affiliated colleges,** **Shivaji University, Kolhapur.**	**The Head,** **Department of Physics,** **Shivaji University, Kolhapur**

Subject: Regarding minor changes in the syllabi of M.Sc.Part-I (Physics) Sem-I & II under the Faculty of Science & Technology.

Sir/Madam,

With reference to the subject mentioned here above, I am directed to inform you that the university authorities have accepted and granted approval to the minor changes in the syllabi of M.Sc.Part-I (Physics) Sem- I & II under the Faculty of Science & Technology.

This minor change in said Syllabus of will be implemented from the academic year 2023-24.

You are therefore, requested to bring this to the notice of all students and teachers concerned.

Thanking you,

Yours faithfully,

Dy. Registrar

Copy to :-

1	The Dean, Faculty of Science & Technology	8	Appointment Section
2	The Chairman, Respective, BOS	9	Centre for Distance Education
3	Exam Section	10	Computer Centre
4	Eligibility Section	11	Affiliation Section (U.G.)
5	O.E. I Section	12	Affiliation Section (P.G.)
6	O.E. II Section	13	P.G.Admission Section
7	O.E. III Section	14	P.G.Seminar Section

SHIVAJI UNIVERSITY, KOLHAPUR - 416004, MAHARASHTRA
PHONE:EPABX–2609000,www.unishivaji.ac.in,bos@unishivaji.ac.in
शिवाजी विद्यापीठ, कोल्हापूर - ४१६००४,महाराष्ट्र
दूरध्वनी - ईपीएबीएक्स - २६०९०००, अभ्यासमंडळे विभाग दुरध्वनी विभाग ०२३१—२६०९०९४
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जा.क्र.शिवाजी वि./अमं/732 दिनांक. 09/10/ 2023

प्रति,

मा. अध्यक्ष व सदस्य,
सर्व अभ्यास/अस्थायी मंडळे (सायन्स)
शिवाजी विद्यापीठ, कोल्हापूर

विषय :— शैक्षणिक वर्षे 2023—24 पासून एम.एस्सी. अभ्यासक्रमाच्या आराखडया (Structure) बाबत.

महोदय/महोदया,

उपरोक्त विषयास अनुसरून आदेशान्वये कळविण्यात येते की, राष्ट्रीय शैक्षणिक धोरण, 2020 ची राज्यातील अंमलबजावणीच्या अनुषंगाने विद्यापीठ अधिकार मंडळाच्या निर्णयानुसार शैक्षणिक वर्षे 2023—24 पासुन एम.एस्सी. अभ्यासक्रमासाठी सोबत जोडलेला कॉमन आराखडा **(Structure)** व **Formatting (Templet)** लागू करण्यात आले आहे याची नोंद घ्यावी.

सदरची बाब सर्व शिक्षक, विद्यार्थी व संबंधीतांच्या निदर्शनास आणावी.

कळावे,

आपला विश्वासू

(डॉ. एस. एम. कुबल)
उपकुलसचिव

प्रत:—

प्र.अधिष्ठाता विज्ञान व तंत्रज्ञान विद्याशाखा
मा.संचालक परीक्षा व मुल्यमापन मंडळ
परीक्षक नियुक्ती विभाग—1,2
सर्व परीक्षा विभाग (ऑन)
माहितीसाठी व पुढील योग्य त्या कार्यवाहीसाठी.

e:\2018-19\sub commite 2018\etc sub committee lettter.doc

Estd. 1962 "A++" Accredited by NAAC(2021) With CGPA 3.52	**SHIVAJI UNIVERSITY, KOLHAPUR - 416 004, MAHARASHTRA** www.unishivaji.ac.in, bos@unishivaji.ac.in **शिवाजी विद्यापीठ, कोल्हापूर - ४१६ ००४,महाराष्ट्र** दूरध्वनी - ईपीएबीएक्स - २६०९०००, अभ्यासमंडळे विभाग दुरध्वनी ०२३१—२६०९०९३/९४	

SU/BOS/Science/499 **Date: 10/07/2023**

To,

The Principal, All Concerned Affiliated Colleges/Institutions Shivaji University, Kolhapur	The Head/Co-ordinator/Director All Concerned Department (Science) Shivaji University, Kolhapur.

Subject: Regarding syllabi of **M.Sc. Part-I (Sem. I & II) as per NEP-2020** degree programme under the Faculty of Science and Technology.

Sir/Madam,

With reference to the subject mentioned above, I am directed to inform you that the university authorities have accepted and granted approval to the revised syllabi, nature of question paper and equivalence of M.Sc. Part-I (Sem. I & II) as per NEP-2020 degree programme under the Faculty of Science and Technology.

M.Sc.-Part I (Sem. I & II) as per NEP-2020			
1.	Microbiology (HM)	10.	Data Science
2.	Pharmaceutical Microbiology (HM)	11.	Computer Science
3.	General Microbiology	12.	Information Technology (Entire)
4.	Electronics	13.	Food Science & Technology
5.	Embedded Technology	14	Food Science & Nutrition
6.	Geology	15.	Biochemistry
7.	Sugar Technology (Entire)	16.	Biotechnology
8.	Alcohol Technology (Entire)	17.	Medical Information Management
9.	Agro Chemical & Pest Management (AGPM)	18.	Environmental Science
		19.	Physics

This syllabus, nature of question and equivalence shall be implemented from the academic year 2023-2024 onwards. A soft copy containing the syllabus is attached herewith and it is also available on university website **www.unishivaji.ac.in**)

The question papers on the pre-revised syllabi of above-mentioned course will be set for the examinations to be held in October /November 2023 & March/April 2024. These chances are available for repeater students, if any.

You are, therefore, requested to bring this to the notice of all students and teachers concerned.

Thanking you,

Dy Registrar
Dr. S. M. Kubal

Copy to:

1	The Dean, Faculty of Science & Technology	8	P.G. Admission/Seminar Section
2	Director, Board of Examinations and Evaluation	9	Computer Centre/ Eligibility Section
3	The Chairman, Respective Board of Studies	10	Affiliation Section (U.G.) (P.G.)
4	B.Sc. Exam/ Appointment Section	11	Centre for Distance Education

SHIVAJI UNIVERSITY, KOLHAPUR

Established: 1962

A++ Accredited by NAAC (2021) with CGPA 3.52

Structure and Syllabus in Accordance with

National Education Policy - 2020

with Multiple Entry and Multiple Exit

Master of Science (Physics)

under
Faculty of Science and Technology

(To Be Implemented From Academic Year 2023-24)

INDEX

1. Preamble

M.Sc. in Physics is a two-year degree program designed to pursue higher studies in Physics at university. Physics is the most fundamental science that seeks to learn and understand natural phenomena in both qualitative and quantitative approaches and gives the solutions to questions raised by human beings. This M.Sc. program focuses on courses that include the core component of Physics and provides optional papers covering almost all branches of Physics. Recently, the various branches of Physics have gained more attention, being one of the bases for modern technology. In view of this, the current programme gives requisite hands-on training to students to encourage them to work in various applied fields in the future.

2. Duration

The Master of Science in PHYSICS Programme shall be A FULL TIME COURSE OF TWO YEARS- FOUR SEMESTER DURATION with 22 Credits per Semester (Total Credits = 88)

3. Eligibility for Admission

ANY GRADUATE FROM RECOGNIZED UNIVERSITIES/HEI is eligible for admission to this course. The criterion for admission is as per the rules and regulations set from time to time by concerned departments, HEIs, university, government, and other relevant statutory authorities.

4. Medium of Instruction

The medium of instruction shall be ENGLISH.

5. Programme Structure

Structure in Accordance with National Education Policy - 2020
With Multiple Entry and Multiple Exit Options
M.Sc. (PHYSICS) Part – I (Level-6.0)

	Course Code	Teaching Scheme			Examination Scheme					
		Theory and Practical			University Assessment (UA)			Internal Assessment (IA)		
		Lectures + Tutorial/ (Hours/ week)	Practical (Hours/ week)	Credit	Maximum Marks	Minimum Marks	Exam. Hours	Maximum Marks	Minimum Marks	Exam. Hours
Semester-I										
Major Mandatory	MSU0325MML936G1	4	--	4	80	32	3	20	8	1
	MSU0325MML936G2	4	--	4	80	32	3	20	8	1
	MSU0325MMP936G1	--	8	4	80	32	3	20	8	1
	MSU0325MMP936G2	--	4	2	40	16	2	10	4	1
Major Elective	MSU0325MEL936G1	4	--	4	80	32	3	20	8	1
Research Methodology	MSU0325RML936G	4	--	4	80	32	3	20	8	1
Total		16	12	22	440			110		
Semester-II										
Major Mandatory	MSU0325MML936H1	4	--	4	80	32	3	20	8	1
	MSU0325MML936H2	4	--	4	80	32	3	20	8	1
	MSU0325MMP936H1	--	8	4	80	32	3	20	8	1
	MSU0325M	--	4	2	40	16	2	10	4	1

	MP936H2									
Major Elective	MSU0325MEL936H1	4	--	4	80	32	3	20	8	1
OJT/FP	MSU0325FPP936H		4	4	*					
Total		12	16	22	440			110		
Total (Sem I + Sem II)		28	28	44						

• MMT–MajorMandatory Theory • MMPR–MajorMandatoryPractical • MET–MajorElective Theory • MEPR–MajorElective Practical • RM - Research Methodology • OJT/FP- On Job Training/ Field Project	• Total Marks for M.Sc.-I : **1100** • Total Credits for M.Sc.-I (Semester I & II) : 44 • ***Separate passing is mandatory for University and Internal Examinations***
*Evaluation scheme for OJT/FP: 70% weightage to report and 30% to presentation	
• **Requirement for Entry at Level 6.0: B. Sc. in Physics (Level 5.5)**	
• **Requirement for Exit after Level 6.0:** **Students can exit after completion of Level 6.0 with Post Graduate Diploma in Physics.**	
• **Requirement for Entry at Level 6.5: Level 6.0 / Post Graduate Diploma in Physics / B.Sc. Honours in Physics (four year program)**	

Structure in Accordance with National Education Policy - 2020
With Multiple Entry and Multiple Exit Options
M.Sc. (PHYSICS) Part – II (Level-6.5)

	Course Code	Teaching Scheme			Examination Scheme					
		Theory and Practical			University Assessment (UA)			Internal Assessment (IA)		
		Lectures + Tutorial (Per week)	Hours (Per week)	Credit	Maximum Marks	Minimum Marks	Exam. Hours	Maximum Marks	Minimum Marks	Exam. Hours
Semester-III										
Major Mandatory	MSU0325MM L916I1	4	--	4	80	32	3	20	8	1
	MSU0325MM L916I2	4	--	4	80	32	3	20	8	1
	MSU0325MM P916I1	--	8	4	80	32	3	20	8	1
	MSU0325MM P916I2	--	4	2	40	16	2	10	4	1
Major Elective	MSU0325ME L916I1	4	--	4	80	32	3	20	8	1
Research Project	MSU0325MM P916I3	--	4	4	#					
Total		12	16	22						
Semester-IV										
Major Mandatory	MSU0325MM L916J1	4	--	4	80	32	3	20	8	1
	MSU0325MM L916J2	4	--	4	80	32	3	20	8	1
	MSU0325MM P916J1	--	8	4	80	32	3	20	8	1
Major Elective	MSU0325ME L916J1	4	--	4	80	32	3	20	8	1
Research Project	MSU0325MM P916J2	--	6	6	##					
Total		12	14	22						
Total (Sem I + Sem II)		24	30	44						

<table>
<tr><td rowspan="3">

- MMT–MajorMandatory Theory
- MMPR–MajorMandatoryPractical
- MET–MajorElective Theory
- MEPR–MajorElective Practical
- RP- Research Project

</td><td>

- Total Marks for M.Sc.-II : **1100**

</td></tr>
<tr><td>

- Total Credits for M.Sc.-II (Semester III & IV) : 44

</td></tr>
<tr><td>

- ***Separate passing is mandatory for University and Internal Examinations***

</td></tr>
<tr><td colspan="2"># Evaluation scheme for research project: 70% weightage to report and 30% to presentation</td></tr>
<tr><td colspan="2">## Evaluation scheme for research project: 70% weightage to report and 30% to presentation</td></tr>
<tr><td colspan="2">

- **Requirement for Exit after Level 6.5:**
  Students can exit after completion of Level 6.5 with Post Graduate in Physics

</td></tr>
</table>

6. Programme Outcomes (POs)

- To create, apply, and disseminate knowledge of Physics in theoretical and experimental domains under different specializations.
- To develop the ability to identify, formulate, analyze, and solve problems in these domains of Physics at both curricular and research level through critical thinking.
- To enable students to apply ICT based skills and making them scientific software literate to use in academics.
- To encourage research culture, provide research ambience and develop related technical proficiency.
- To develop attitude to pursue further research.
- To inculcate academic and social ethical values among the students.

7. Course Codes

M.Sc. Semester-I		
Sr. No.	**Major Mandatory**	
1	Mathematical Physics (4 credit)	**MSU0325MML936G1**
2	Classical Mechanics (4credit)	**MSU0325MML936G2**
3	Practical Lab-I (4credit)	**MSU0325MMP936G1**
4	Practical Lab-II (2credit)	**MSU0325MMP936G2**
5	Research Methodology (4credit)	**MSU0325RML936G**
6	**Major Elective**	
	Solid State Physics-1 (4 credit)	**MSU0325MEL936G1**
	Space Physics-1 (4 credit)	**MSU0325MEL936G2**
	Theoretical Physics-1 (4 credit)	**MSU0325MEL936G3**
	Modern Optics–1 (4 credit)	**MSU0325MEL936G4**
	Energy Science–1 (4 credit)	**MSU0325MEL936G5**
	Material Science-1 (4 credit)	**MSU0325MEL936G6**
M.Sc. Semester-II		
	Major Mandatory	
1	Quantum Mechanics (4 credit)	**MSU0325MML936H1**
2	Condensed Matter Physics (4 credit)	**MSU0325MML936H2**
3	Practical Lab-III (4 credit)	**MSU0325MMP936H1**
4	Practical Lab-IV (2 credit)	**MSU0325MMP936H2**
5	Field Project (4 credit)	**MSU0325FPP936H**
6	**Major Elective**	
	Solid State Physics-2 (4 credit)	**MSU0325MEL936H1**
	Space Physics-2 (4 credit)	**MSU0325MEL936H2**
	Theoretical Physics-2 (4 credit)	**MSU0325MEL936H3**
	Modern Optics-2 (4 credit)	**MSU0325MEL936H4**
	Energy Science-2 (4 credit)	**MSU0325MEL936H5**
	Material Science-2 (4 credit)	**MSU0325MEL936H6**

Sr. No.	M.Sc. Semester-III	
	Major Mandatory	
1	Statistical Mechanics (4 credit)	**MSU0325MML916I1**
2	Atomic and Molecular Physics (4 credit)	**MSU0325MML916I2**
3	Practical Lab-V (4 credit)	**MSU0325MMP916I1**
4	Practical Lab-VI (2 credit)	**MSU0325MMP916I2**
5	Research Project (4 credit)	**MSU0325MMP916I3**
6	**Major Elective**	
	Solid State Physics-3 (4 credit)	**MSU0325MEL916I1**
	Space Physics-3 (4 credit)	**MSU0325MEL916I2**
	Theoretical Physics-3 (4 credit)	**MSU0325MEL916I3**
	Modern Optics-3 (4 credit)	**MSU0325MEL916I4**
	Energy Science-3 (4 credit)	**MSU0325MEL916I5**
	Material Science-3 (4 credit)	**MSU0325MEL916I6**
	M.Sc. Semester-IV	
	Major Mandatory	
1	Electrodynamics (4 credit)	**MSU0325MML916J1**
2	Nuclear and Particle Physics (4 credit)	**MSU0325MML916J2**
3	Practical Lab-VII (4 credit)	**MSU0325MMP916J1**
4	Research Project (6 credit)	**MSU0325MMP916J2**
5	**Major Elective**	
	Solid State Physics-4 (4 credit)	**MSU0325MEL916J1**
	Space Physics-4 (4 credit)	**MSU0325MEL916J2**
	Theoretical Physics-4 (4 credit)	**MSU0325MEL916J3**
	Modern Optics-4 (4 credit)	**MSU0325MEL916J4**
	Energy Science-4 (4 credit)	**MSU0325MEL916J5**
	Material Science-4 (4 credit)	**MSU0325MEL916J6**

TABLE FOR STEPWISE CODE ASSIGNMENT TO PAPER

COLUMN No.	1	2	3	4	5	6	7	8
Name	PROGRAM CODE	INSTITUTE CODE	COURSE CATEGORY	NATURE OF COURSE CODE	LEVEL OF COURSE CODE	SR. NO. OF COURSE CODE	SEMESTER	COURSES
Details of coding	**MS**	**U0325**	**MM/ME/RM/OJ/FP**	**L/P/T**	**9**	**36**	**G/H/I/J**	**1/2/3/4/…**
Explanation		SUK code, Refer.	Major Mandatory (MM), Major Elective (ME), Research Methodology (RM), On Job Training (OJ), Field Projects (FP)	Lecture (L), Practical (P), Tutorial (T)	Refer *Annexure 1*.	Course Code For Physics is 36. For other courses refer *Annexure 2*.	SEM I: G SEM II: H SEM III: I SEM IV: J	- Course Number, also referred to as Paper Number, is only assigned for Major Mandatory (MM) and Major Elective (ME) courses. - No Course Numbers will be assigned for Research Methodology (RM), On Job Training (OJ), and Field Projects (FP).

COLUMN 1. Program Code Assignment

- The program code for Science Master programs is designated as "MS"

COLUMN 2. Institute Code Assignment

- The Institute Code for Shivaji University is identified as "U0325"
- For further reference, please refer to *Annexure 1*.

COLUMN 3. Course Category Assignment

- As per guidelines of NEP 2020 the Course Category is assigned based on the nature of the course and is categorized into the following:
  - Major Mandatory (MM)
  - Major Elective (ME)
  - Research Methodology (RM)
  - On Job Training (OJ)
  - Field Projects (FP)

- Choose any one which is applicable foryour course

COLUMN 4. Course Code Assignment

- Depending on the nature of the course, the following codes are used:
  - Lecture (L)
  - Practical (P)
  - Tutorial (T)

- Choose any one which is applicable for your course

COLUMN 5. Course Code Level

- The level of the course code for all master programs is set to 9.
- For further reference, please see *Annexure 2*. For further information please refer:

Guidelines for Multiple Entry and Exit in Academic Programmes offered in Higher Education Institutions (https://www.education.gov.in/sites/upload_files/mhrd/files/upload_document/abc_doc.pdf)

COLUMN 6. Serial Number of Course Code

- The serial number of course code is added based on the Science Faculty's course code list provided by BOS, Shivaji University, Kolhapur.
- For the complete list of course codes for Science Faculty, please refer to *Annexure 2*.

- Choose appropriate serial number which is applicable for your course

COLUMN 7. Semester Code Assignment

- The Semester Code is assigned as follows:
  - SEM I: G
  - SEM II: H
  - SEM III: I
  - SEM IV: J

- Choose appropriate semester code which is applicable for your course

COLUMN 8. Course Number Assignment

- Course Number, also referred to as Paper Number, is only assigned for Major Mandatory (MM) and Major Elective (ME) courses.
- No Course Numbers will be assigned for Research Methodology (RM), On Job Training (OJ), and Field Projects (FP).

For example: first MM/ME course will have course number 1, second MM/ME course will have course number 2 likewise.

*Note: This SOP is intended to streamline and maintain consistency in the paper codeassignment process for Science Master programs at Shivaji University.

Examples for reference:

The course code for M.Sc. Physics Semester 1 course is as follows:

MS	**U0325**	**MM**	**L**	**9**	**36**	**G**	**1**
1	2	3	4	5	6	7	8

M.Sc. Semester-I		
Sr. No.	**Major Mandatory**	
1	Mathematical Physics (4 credit)	**MSU0325MML936G1**
2	Classical Mechanics (4 credit)	**MSU0325MML936G2**
3	Practical Lab-I (4 credit)	**MSU0325MMP936G1**
4	Practical Lab-II (2 credit)	**MSU0325MMP936G2**
5	Research Methodology (4 credit)	**MSU0325RML936G**
6	**Major Elective**	
	Solid State Physics-1 (4 credit)	**MSU0325MEL936G1**
	Space Physics-1 (4 credit)	**MSU0325MEL936G2**
	Theoretical Physics-1 (4 credit)	**MSU0325MEL936G3**
	Modern Optics–1 (4 credit)	**MSU0325MEL936G4**
	Energy Science–1 (4 credit)	**MSU0325MEL936G5**
	Material Science-1 (4 credit)	**MSU0325MEL936G6**

M.Sc. Semester-II		
	Major Mandatory	
1	Quantum Mechanics (4 credit)	**MSU0325MML936H1**
2	Condensed Matter Physics (4 credit)	**MSU0325MML936H2**
3	Practical Lab-III (4 credit)	**MSU0325MMP936H1**
4	Practical Lab-IV (2 credit)	**MSU0325MMP936H2**
5	Field Project (4 credit)	**MSU0325FPP936H**
6	**Major Elective**	
	Solid State Physics-2 (4 credit)	**MSU0325MEL936H1**
	Space Physics-2 (4 credit)	**MSU0325MEL936H2**
	Theoretical Physics-2 (4 credit)	**MSU0325MEL936H3**
	Modern Optics-2 (4 credit)	**MSU0325MEL936H4**
	Energy Science-2 (4 credit)	**MSU0325MEL936H5**
	Material Science-2 (4 credit)	**MSU0325MEL936H6**

Annexure 1

Table-I

Qualification Type and Credit Requirements		
Levels	**Qualification title**	**Credit requirements**
Level 5	Undergraduate Certificate (in the field of learning/discipline) for those who exit after the first year (two semesters) of the undergraduate programme. (Programme duration: first year or two semesters of the undergraduate programme)	36–40
Level 6	Undergraduate Diploma (in the field of learning/discipline) for those who exit after two years (four semesters) of the undergraduate programme (Programme duration: First two years or four semesters of the undergraduate programme)	72–80
Level 7	Bachelor' Degree (Programme duration: Three years or six semesters).	108–120
Level 8	Bachelor' Degree (Honours/Research) (Programme duration: Four years or eight semesters).	144–160
Level 8	Post-Graduate Diploma for those who exit after the successful completion of the first year or two semesters of the two-year Master's degree programme). (Programme duration: One year or two semesters)	36–40
Level 9	Master's Degree (Programme duration: Two years or four semesters after obtaining a Bachelor's degree).	72–80
Level 9	Master's Degree (Programme duration: One year or two semesters after obtaining a four-year Bachelor's Degree (Honours/Research).	36–40
Level 10	Doctoral Degree	Minimum prescribed credits for course work and a thesis with published work

Annexure 2

M.Sc. Course Code List

Code No.	Branch Name	Code. No.	Branch Name
1	Agrochemical and Pest Management	20	Geoinformatics
2	Alcohol Technology	21	Geology
3	Analytical Chemistry	22	Industrial Chemistry
4	Applied Chemistry	23	Information Technology
5	Applied Statistics and Informatics	24	Inorganic Chemistry
6	Biochemistry	25	Mathematics
7	Biotechnology	26	Mathematics (Distance)
8	Botany	27	Mathematics (Online Mode)
9	Computer Science	28	Mathematics with Computer Science
10	Computer Science (Online Mode)	29	MCA Science 2 Year Course
11	Data Science	30	Medical Information Management
12	Electronics	31	Microbiology
13	Embedded Technology	32	Nanoscience and Technology
14	Environmental Biotechnology	33	Organic Chemistry
15	Environmental Science	34	Pharmaceutical Microbiology
16	Food Science & Nutrition	35	Physical Chemistry
17	Food Science & Technology	36	Physics
18	General Microbiology	37	Statistics
19	Geography	38	Sugar Technology
		39	Zoology

8. Syllabus

M. Sc. Physics (Part I) (Level-6.0) (Semester I)
(NEP-2020)
(Introduced from Academic Year 2023-24)

M.Sc. (Physics) NEP-Semester-I
Course Code: MSU0325MML936G1
Paper title: Mathematical Physics (MP)
Total Credits: 4-credits

Mathematical Physics

Unit - I: Vector Spaces and matrices (15)

Linear vector space (Rajput 123 – 126), Matrix multiplication – inner product, direct product, diagonal matrices, trace, matrix inversion, example of Gauss-Jordon inversion, problems (Rajput 735 – 45). eigen values and eigen vectors, properties of eigen values and eigen vectors, Cayley- Hamilton theorem and applications, similar matrices, and diagonalizable matrices, eigen values of some Special complex matrices, quadratics forms, problems.

Unit - II: Differential equations and Special functions (15)

Solution for first order differential equation, Bernulli equation, exact equation, second order linear differential equation with constant and variable coefficient, special functions (Hermite, Bessel, Laguerre, and Legendre functions) generating functions, recurrence relation (Rajput 510 –667)

Unit - III: Fourier- Series, Integral, and Transform (15)

Definition, evaluation of coefficients of Fourier series (Cosine and Sine Series), graphical representation of a square wave function, complex form of Fourier series, Fourier integral exponential form, applications of Fourier series analysis in physics (square wave, full wave rectifier, expansion of Raman Zeta function) (Rajput 527 – 561). Fourier transform, inversion theorem, exponential transform Example: full wave train, uncertainty principle [Arfken 931-946]. Dirac delta function, derivative of δ- function and Laplace Transform of δ- function (Rajput1467 – 1475).

Unit – IV: Complex Analysis (15)

Analytical functions, Cauchy-Riemann conditions, Cauchy's theorem, Cauchy integral formula, derivatives of analytical functions, Taylor's theorem, Laurent's theorem, residues, evaluation of definite integrals (Rajput 404-499)

Reference book:

1) Rajput B. S., Mathematical Physics, Pragati Prakashan (Meerat) 1999
2) Iyengar S. R. K., Jain R. K., Mathematical Methods, Narosa, 2006
3) Arfken and Weber, Mathematical Methods for Physicists 6th Edition, Academic Press, 2005
4) Mathematical Physics, Binoy Bhattacharyya, New Central Book Agency (P) Limited, 2010
5) Complex Variables and Applications – J. W. Brown, R. V. Churchill – (7th Edition) - Mc-Graw Hill – Ch. 2 to 7.
6) Complex Variables –Seymour Lipschutz, John J. Schiller, Dennis Spellman, (2^{nd} Edition) Mc-Graw Hill – 2009.

M.Sc. (Physics) NEP -Semester-I
Course Code: MSU0325MML936G2
Paper title: Classical Mechanics (CM)
Total Credits: 4-credits

Classical Mechanics

Unit - I: Central Force Problem and Small oscillations: (15)

Two body problem, The equation of motion and first integrals, Equation of orbit, Kepler's laws, Kepler's problem, General analysis of orbits, Stability of orbits, Rutherford Scattering: Differential scattering cross–section, Rutherford Formulae for scattering, Virial theorem. Small oscillations: Potential energy and equilibrium-one dimensional oscillator, general theory of small oscillations.

Unit - II: Variational principle and Hamiltonian Dynamics: (15)

Variational principle, Deduction of canonical equations from Variational principle, Principle of least action with proof, Hamilton's principle, Hamiltonian, Generalized momentum & Conservation Theorems using cyclic coordinates, Hamilton's canonical equations of motion, Applications of Hamilton's equations of motion-1) Simple Pendulum 2) Compound Pendulum 3) Linear Harmonic Oscillator.

Unit - III: Canonical Transformations and Poisson's Brackets: (15)

Legendre transformations, Generating Functions, Illustrations of Canonical transformations, Condition for Canonical Transformation, Examples. Poisson's Brackets, Poisson's theorem, Properties of Poisson's Brackets, **Lagrange Bracket, Relation between Lagrange and Poisson's Brackets**, Hamilton's Canonical equations in terms of Poisson's Brackets, Hamilton–Jacobi Theory, Solution of harmonic oscillator problem by HJ Method, Problems.

Unit - IV: Special Theory of Relativity and Relativistic Mechanics: (15)

Special theory of relativity and its postulates, Galilean transformations, Lorentz transformations **relativistic kinematics** (Relativity of Mass, Length, Time), Minkowski Space, 4-Vectors, 4-Momentum, Lorentz Tensor, Addition of velocities, Mass-Energy relation, Force in relativistic mechanics, Lagrangian formulation of relativistic mechanics, Particle accelerating under constant force, Hamiltonian formulation of relativistic mechanics, Relativistic Doppler's Effect.

Reference Books:

1. Classical Mechanics, by H Goldstein (Addison Wesley 1980).
2. Classical Mechanics, by J. C. Upadhyaya (Himalaya Publishing House 2015).
3. Classical Mechanics, by N. C. Rana and P. S. Joag (Tata McGraw Hill 1991).
4. Introduction to Classical Mechanics, by R. G. Takwale and P. S. Puranik (Tata McGraw Hill 1999).
5. Classical Mechanics, by Gupta, Kumar, and Sharma (Pragati Prakashan 2000).

M.Sc. (Physics) NEP -Semester-I
Course Code: MSU0325RML936G
Paper title: Research Methodology (RM)
Total Credits: 4-credits

Research Methodology

Unit-I Research Methodology: (15)

a) Meaning of research, objectives of research, motivation in research, types of research, research approaches, significance of research, research methods versus research and scientific methodology, importance of knowing how research is done, research progress, criteria of good research.

b) Research design: meaning of research design, features of good design, important concepts of relating research design, different basic designs.

c) Method of data collection, types of data analysis; statistics in research, measure of central tendency, measure of dispersion; measure of asymmetry, measure of relationship, simple regression analysis, multiple correlation and regression, partial correlation.

Unit-II Literature Searching and Report Writing: (15)

a) Literature Searching: On-line searching, Database, SciFinder, Scopus, Science Direct, CA on CD, Searching research articles, Citation Index, Impact Factor, H-index etc,

b) Writing scientific report: Structure and components of research report, revision, and refining' writing project proposal, Paper writing for International Journals, submitting to editors. conference presentation, preparation of effective slides, pictures, graphs, and citation styles.

c) Thesis writing: the preliminary pages and the introduction, the literature review, methodology, the data analysis chapters, the conclusion

Unit III Vacuum (15)

Production of low pressures: rotary, diffusion, and sputter ion pumps; measurement of low pressure: McLeod, Pirani, thermocouple & Penning gauges; leak detection: simple methods of LD, palladium barrier and halogen leak detectors.

Unit IV Low Temperature and Microscopy Techniques (15)

Production of low temperatures: Adiabatic cooling, the Joule-Kelvin expansion, adiabatic demagnetization, 3 He cryostat, the dilution refrigerator, principle of Pomerunchuk cooling, principle of nuclear demagnetization; measurement of low temperatures. Optical microscopy, scanning electron microscopy, electron microprobe analysis, low energy electron diffraction.

Reference Books

1.Fundamentals of computers, Morley & Parkar, Cengage Learning Pvt. Ltd. New Delhi,
2.Research Methodology – Methods and Techniques, C. R. Kothari, Wiley Easter Ltd, New Delhi 1985.
3. Writing your thesis, Paul Oliver, Vistaar Publication, New Delhi
4. High vacuum techniques- J. Yarwood (Chapman & Hall) 1967
5. Vacuum technology- A. Roth (North-Holland Publishing Company, Amsterdam) 1982
6. Experimental techniques in low temperature physics – G. K. White (Oxford) 1968
7. Low temperature physics – L.C. Jackson

M. Sc. I (Physics) NEP- Semester I
Course Code: MSU0325MMP936G1
Paper title: Physics LAB-I
Total Credits: 4-credits

Laboratory/ Practical Course-I
(Two experiments and certified journal- 4-credits)

1. Hall effect (Hall coefficient & carrier concentration of semiconductor).
2. Linear Variable Differential Transducer.
3. Crystal structure identification by Neutron diffraction pattern.
4. Wavelength of given source by using Fabry-Parrot etalon.
5. Crystal structure identification by X- ray diffraction pattern.
6. Structure identification of given samples (F.C.C.& B.C.C.)
7. Monatomic/ diatomic lattice vibrations using lattice dynamics kit.
8. Characteristic of Temperature Transducers (Thermocouple, Thermistor and IC sensor)
9. Specific heat capacity of given metals.
10. Staircase Ramp Generator using UJT
11. Negative feedback amplifier (with and without feedback)
12. Astable multivibrator
13. Monostable multivibrator.
14. Stefan's constant.
15. Magnetic parameters of given sample using B-H curve kit
16. Thermal & electrical conductivity of copper.
17. Numerical, algebraic, and trigonometric problems using Mathematica.
18. Analysis of statistical data.
19. Numerical differentiation using Python.
20. Numerical integration using Python.
21. Physical density of material by using Archimedes' Principle.

M. Sc. (Physics) NEP -Semester-I
Course Code: SU0325MMP936G2
Paper title: Physics LAB-II
Total Credits: 2-credits

Laboratory/ Practical Course-II
(Seminar & certified seminar report 1-credits +Tutorials on practical-1-credits)
Total Credits: 2-credits

Elective Paper

(Choose any one from Specialization)

Sr. No.	Course Code	Paper Title
1	SSP-1	Semiconductor Physics (4 credits)
2	SP-1	Stellar Evolution: Birth, Evolution and Death of the Stars (4 credits)
3	TH-1	Fundamentals of Plasma Physics (4-credits)
4	MO-1	Laser Physics (4-credits)
5	ES-1	Renewable Energy Resources – I (4 credits)
6	MS-1	Imperfection in crystals (4 credits)

M.Sc. (Physics) NEP Semester-I
Course Code: MSU0325MEL936G1
Paper title: Semiconductor Physics
Total Credits: 4-credits

(Solid State Physics-1)
Semiconductor Physics

Unit I: Energy Bands and Charge Carriers in Semiconductors: (15)
Direct and Indirect semiconductors, variation of energy bands with alloy composition, Charge carriers in semiconductors: electrons and holes, effective mass, intrinsic and extrinsic materials, electrons and holes in quantum wells, The Fermi level, carrier concentration at equilibrium, temperature dependence, space charge neutrality, conductivity and mobility, Drift and resistance, effects of temperature and doping on mobility, the Hall effect.

Unit II: Excess Carriers in Semiconductors: (15)
Optical absorption, Luminescence: photoluminescence and electroluminescence, Direct recombination of electrons and holes, Indirect recombination and trapping, steady state carrier generation and Quasi Fermi levels, Diffusion processes, Diffusion and Drift of carriers, built-in fields, The continuity equation, steady state carrier injection, diffusion length,

Unit III: Junctions-I (15)
Fabrication of p-n junctions; Thermal oxidation, diffusion, CVD, Photolithography, etching, metallization, The contact potential, Space charge at a junction, qualitative description of current flow at a junction, reverse-bias breakdown, Capacitance of p-n junctions, Zener and Avalanche breakdown, rectifiers.

Unit IV: Junctions-II (15)
The tunnel diode, the Varactor diode, recombination, and generation in the transition region, ohmic losses, graded junctions, Schottky barriers, rectifying contacts, ohmic contacts, hetero-junctions, AlGaAs-GaAs hetero-junction.

References:
1. Solid state electronic devices by B. G. Streetman.
2. Physics of semiconductor devices by S. M. Sze.
3. Solid State and Semiconductor Physics by McKelvey.
4. Principles of Electronic Materials and Devices by S.O. Kasap

M.Sc. (Physics) NEP- Semester-I
Course Code: MSU0325MEL936G2
Paper title: Stellar Evolution: Birth, Evolution and Death of the Stars
Total Credits: 4-credits

(Space Physics - I)
Stellar Evolution: Birth, Evolution and Death of the Stars

Unit-I: Formation of the Stars (15)
Interstellar Medium-nebulae, extinction and reddening, interstellar absorption lines, radio observations of the interstellar medium, Birth of Stars-contraction and heating, protostar, star formation confirmed, T-Tauri stars, Herbig-Haro objects, bipolar flow, Sources of Stellar Energy-solar energy generation, proton-proton chain, solar neutrino mystery, hydrogen fusion in star, CNO-cycle, energy transport, hydrostatic equilibrium, the pressure-temperature thermostat.

Unit-II: Stellar Evolution (15)
H-R diagram, Main Sequence Stars-stellar models, end of main sequence, the mass luminosity relation, life of main sequence star, post main sequence star evolution expansion into giant, helium fusion, fusion of elements heavier than helium, Variable Stars-Cepheid variables, pulsating stars, Star Cluster-observing star cluster, stellar evolution confirmed, open cluster and globular cluster.

Unit-III: Death of the Stars (15)
Lower Main Sequence stars-Red Dwarfs, Sun-like stars, Mass loss from stars, planetary nebulae, white dwarfs, black dwarf Chandrasekhar Limit, Upper Main evolution of upper main sequence stars-hydrogen, helium carbon core formation, carbon detonation, the iron core, supernova, observations of supernova, type-I and Type-II supernova, supernova remnant, synchrotron radiation, Evolution of Binary Stars-Mass transfer, recycled stellar evolution, accretion disks.

Unit-IV: Neutron Stars and Black Holes (15)
Neutron stars, properties of neutron stars, Pulsars, Pulsar model, the evolution of Pulsars, binary Pulsars, quasi-periodic objects, bursters, black holes-escape velocity, Schwarzschild Black holes, Schwarzschild radius, Kerr black holes, leaping in, time dilation, gravitational red shift, search for black holes.

Reference Books:
1. Foundations of Astronomy by Michael a. Seeds
2. An Introduction to Birth, Evolution and Death of the Stars by James Lequeux
3. An Introduction to the Theory of Stellar Structure and Evolution by Dina Prialnik
4. Astronomy The Evolving Universe by Michael Zeilik
5. A Brief History of Time, by Stephen Hawking
6. Our Cosmic Origins - From the Big Bang to the Emergence of Life and Intelligence
by Armand H. Delsemme

M.Sc. (Physics) NEP -Semester-I
Course Code: MSU0325MEL936G3
Paper title: Fundamentals of Plasma Physics
Total Credits: 4-credits

(Theoretical Physics-I)
Fundamentals of Plasma Physics

Unit I: Introduction (15)

Occurrence of Plasmas in Nature, Definition of Plasma, Concept of Temperature, Debye Shielding, The Plasma Parameter, Criteria for Plasmas, Applications of Plasma Physics. Single-Particle Motions: Introduction, Uniform E and B Fields, Non-uniform B Field, Non-uniform E Field, Time Varying E Field, Time-Varying B Field, Summary of Guiding Center Drifts, Adiabatic Invariants.

Unit II: Plasmas as Fluids (15)

Introduction, Relation of Plasma Physics to Ordinary Electromagnetics, The Fluid Equation of Motion, Fluid Drifts Parallel and Perpendicular to B, The Plasma Approximation.

Waves in Plasmas: Waves in Plasmas Representation of Waves, Group Velocity, Plasma Oscillations, Electron Plasma Waves, Sound Waves, Ion Waves, Validity of the Plasma Approximation, Comparison of Ion and Electron Waves, Electrostatic Electron Oscillations Perpendicular to B, Electrostatic Ion Waves Perpendicular to B, The Lower Hybrid Frequency, Electromagnetic Waves with B_0=0, Electromagnetic Waves Perpendicular to B_0, Cut-offs and Resonances, Electromagnetic Waves Parallel to B_0.

Unit III: Diffusion and Resistivity (15)

Diffusion and Mobility in Weakly Ionized Gases, Decay of a Plasma by Diffusion, Steady State Solutions, Recombination, Diffusion Across a Magnetic Field, Collisions in Fully Ionized Plasmas, The Single-Fluid MHD Equations, Diffusion of Fully Ionized Plasmas, Solutions of the Diffusion Equation, Bohm Diffusion and Neoclassical Diffusion.

Unit IV: Kinetic Theory (15)

The Meaning of f(v), Equations of Kinetic Theory, Derivation of the Fluid Equations, Plasma Oscillations and Landau Damping, The Meaning of Landau Damping, A Physical Derivation of Landau Damping, Ion Landau Damping, Kinetic Effects in a Magnetic Field.

Nonlinear Effects Introduction, Sheaths, Ion Acoustic Shock Waves, The Ponderomotive Force, Parametric Instabilities, Plasma Echoes, Nonlinear Landau Damping, Equations of Nonlinear Plasma Physics, Reconnection, Turbulence, Sheath Boundaries.

References

1. Introduction to Plasma Physics and Controlled Fusion by Francis F. Chen (3rd Springer International Edition, 2016).
2. Fundamentals of Plasma Physics by Paul M. Bellan, Cambridge University Press (1st Paperback Edition,2008).
3.Fundamentals of Plasma Physics, by J. A. Bittencourt, (3rd Edition) Springer-Verlag. (2004)
4. Plasma Physics: An Introduction by Richard Fitzpatrick, CRC Press, (2014)
5. Elements of Plasma Physics by S N Goswami (2016)

M.Sc. (Physics) NEP- Semester-I
Course Code: MSU0325MEL936G4
Paper title: Laser Physics
Total Credits: 4-credits

(Modern Optics - I)
Laser Physics

Unit I: Laser fundamentals **(15)**
Laser Fundamentals: Laser idea, Attainment of population inversion, Properties of laser beams, Optical pumping, Laser pumping, Electrical pumping, pumping rate and pump efficiency, **Resonators:** Plane – parallel resonator, concentric resonator, confocal resonator, resonators using a combination of plane and spherical mirrors, confocal resonator, Line shape function, Laser modes.

Unit II: Laser Behavior **(15)**
Continuous wave laser behavior: Rate equations in 3 level and 4 level laser systems, CW behavior, Optimum output coupling, limit to monochromaticity and frequency pulling.
Transient laser behavior: Step– pump pulse, single mode oscillation, multimode oscillation, Q – Switching, methods of Q – switching, Mode locking, methods of Mode locking, modes of resonator system.

Unit – III: Solid state, Dye and Semiconductor Lasers **(15)**
Solid state lasers: The Ruby laser, Nd: YAG laser, Nd: Glass lasers, Fiber lasers.
Dye Lasers: Characteristics of Dye lasers, Rate equations for Dye lasers.
Semiconductor Lasers: Principle of semiconductor laser, Homojunction and Heterostructure lasers, Laser Diode Characteristics.

Unit – IV: Gas, chemical, electron Lasers and Applications of lasers: **(15)**
Gas Lasers: Process of excitation and de-excitation in gas lasers, Neutral-Atom gas laser, Ion lasers, Metal Vapor lasers, Molecular gas lasers: CO_2laser system, Vibronic lasers, Excimer laser, Chemical Lasers, Free electron lasers, X-ray lasers
Applications of lasers: Applications of laser in science, Industrial Applications, Light Wave Communications, Optical data processing and Holography.

Reference Books:

1. Principles of Lasers- Orazio Svelto, Springer, Fourth edition.
2. Lasers: Fundamentals and Applications- K. Thyagarajan, Ajay Ghatak, Springer, Second edition
3. J. Wilson and J.F.B. Hawkes. Laser Principles and Applications, Prentice Hall International, NY, (1987).
4. Laser Fundamentals- W.T. Silvafast, Cambridge University Press, second edition.
5. Laser Physics-L.V. Tarasov, Mir publishers, Moscow.
6. Siegman, An Introduction to Laser and Masers, McGraww Hill Book Co., (1971).
7. Introduction to Laser Physics-B.A. Lengyl,
8. Optical Holography- R.J. Collier.

M.Sc. (Physics) NEP- Semester-I
Course Code: MSU0325MEL936G5
Paper title: Renewable Energy Resources-I
Total Credits: 4-credits

(Energy Studies- I)
Renewable Energy Resources-I

Unit I: Energy and Thermodynamics (15)
Dimensions and Conversions for Energy, Concepts of Energy, Heat and Work, $1^{st}$and 2^{nd} law of Thermodynamics (Closed and Open Systems), Thermodynamics Power Cycles, Reversible Heat Engine Cycle, IC Engine Cycles, Carnot Cycle, Rankine Cycle, Otto Cycle, Vapor Refrigeration and Power Cycle etc.

Unit II :Conventional energy resources (15)
Fossil fuels, time scale of fossil fuels, Different forms of fossil fuels: Coal, oil and Natural Gas, their Reserves, Global and Indian Scenario, Energy production using coal, oil, and natural gas;
Nuclear Power plants: nuclear fission and chain reaction, Power generation in nuclear power plants: Reactor types. Hydropower plants: Classification of Hydropower Plants, Small Hydropower Systems: mini, micro and pico systems, Pumped storage plants, Hydraulic Turbines: classification and operational aspects, elements of turbine, selection, and design criteria.

Unit-III: Environmental Impacts of Energy systems
Energy flow diagram to the earth, Carbon cycle, Environmental degradation due to energy production and utilization (with context to conventional energy sources), Primary and Secondary pollution due to Green House Gases Emission such as SOx, NOx, SPM in air, thermal and water pollution, depletion of ozone layer, global warming, Positive and Negative Impacts, biological damage due to environmental degradation. Environmental issues related to hydro projects Case studies: pollution due to thermal power plants and nuclear power plants. Energy Consumption in India, Energy crises, Need of renewable energy sources

Unit-IV: Solar Energy for Clean Environment
Sun as the source of energy and its energy transport to the earth, Nature of Solar Radiation, Global, direct and Diffuse Radiation, Hourly, Daily and Seasonal variation of solar Radiation, Estimation of Solar Radiation, Measurement of direct and diffuse Solar Radiations.

Reference Book
1) Sorensen B., “Renewable Energy”, Second Edition, Academic Press, 2000.
2) Solar Energy and Rural development- S.H. Pawar, C.D. Lokhande and R.N. Patil.
3) Solid State Energy Conversion-S.H. Pawar, C.H. Bhosale, and R.N. Patil
4) Solar Energy Conversion-A.E. Dixon and J.D. Leslie.
5) Advances in Energy systems and technology- Peter Auer

M.Sc. (Physics) NEP Semester-I
Course Code: MSU0325MEL936G6
Paper title: Imperfection in Crystals
Total Credits: 4-credits

(Material Science -I)
Imperfection in Crystals

Unit I: Point defects **(15)**

Crystalline materials, Types of Defects in crystalline materials (Point Defects, Stacking Faults, Grain Boundaries, Twin Boundaries, Volume Defects) Point defects in metallic and non-metallic crystals, lattice distortion, migration energy, point defects in thermal equilibrium, point defects in ionic crystals, equilibrium concentration of Frenkel and Schottky defects, ionic conductivity, point defects in non-thermal equilibrium.

Unit II: Dislocations **(15)**

Concept and types of dislocation, Dislocations and non-uniform slip, Edge dislocation, Screw dislocation, Curved dislocation line on plane slip surface, Effect of atomic structure on the form of a dislocation (Central force approximation, Bubble model, Directional bonds, Cottrell atmosphere, imperfect or partial dislocations, stacking faults) Thomson tetrahedron, partial dislocations in other crystal structures, multiplication of dislocations, Jogs and their formation, motion of a vacancy jog, measurement of stacking fault energy.

Unit III: Diffusion and Solidification **(15)**

Diffusion: Fick's laws of diffusion, solutions to the diffusion equation, calculation of jump frequency, mechanisms of diffusion, self-diffusion, diffusion - along grain boundaries.
Solidification: Homogeneous nucleation, heterogeneous nucleation, atomic kinetics, solute manipulation (normal freezing, zone melting & zone refining).

Unit IV: Principles and applications of phase diagrams **(15)**

Freezing of a pure metal, Plane-front and dendritic solidification at a cooled surface, Gas porosity and segregation, Directional solidification, Production of metallic single crystals for research, The concept of a phase, The Phase Rule, Stability of phases, Two-phase equilibria, Three-phase equilibria and reactions, Intermediate phases, Limitations of phase diagrams.

Reference Books:

1) Physical metallurgy - R.W. Cahn, II Edition, North Holland, Amsterdam (1970)
2) Introduction to dislocations - D. Hull, ELBS (1971)
3) Imperfections in crystals - Van Burren, North Holland (1960)
4) Theory of crystal dislocations - F.R.N. Nabarro, Clarendon Press (1968)
5) Dislocations in crystals - W.T. Read, McGraw Hill (1953)
6) Modern physical metallurgy - R.E. Smallman, Butterworths (1970)
7) Techniques of metal research - R.F. Bunshaw, Interscience (1968)
8) Modern techniques in metallography - D.G. Brandon, Butterworths (1966)
9) Introduction to properties of engineering materials- K.J. Pascoe, Blackie and Sons, London (1968).
10) William F Smith, Javad Hashemi, Ravi Prakash, Mater. Sci. and Eng., Tata-McGraw Hill, 4th Edition

11) R. E. Smallman and A. H.W. Ngan, Physical Metallurgy and Advanced Materials (Seventh Edition), Published by Elsevier Ltd, 2007.

M. Sc. - I (Semester-II)

M.Sc. (Physics) NEP-Semester-II
Course Code: MSU0325MML936H1
Paper title: Quantum Mechanics
Total Credits: 4-credits

Quantum Mechanics

Unit-I: Mathematical Tools of Quantum Mechanics (15)

Hilbert space and wave function, Dirac notations, Operators (General definitions, Hermitian adjoint operator, projection operators, uncertainty relation between two operators, functions of operators, inverse and unitary operators, eigenvalues and eigenvectors of an operator, parity Representation in continuous bases (Position representation, Momentum representation and connection between them), Matrix representation of orbital and spin angular momentum.

Unit-II: Variational Method and WKB Approximation (15)

The variational principle, Rayleigh-Ritz method, variational method for excited states, the Hellmann-Feynman theorem, ground state of harmonic oscillator, infinite square well, hydrogen atom, the WKB method, the connection formulas, validity of WKB method, barrier penetration, Alpha emission.

Unit-III: Perturbation Theory (15)

Time independent perturbation: basic concept, non-degenerate energy levels, Eigen value of energy and Eigen function in the first order approximation, Anharmonic oscillator: first order correction, first order correction to ground state of helium. The pictures of quantum mechanics (Schrodinger picture, Heisenberg picture and Interaction picture), Time dependent perturbation: Basic concept, Dyson series, First-order perturbation, transition probability, constant perturbation, harmonic perturbation, transition to continuum states (Fermi-Golden rule), semi-classical theory of radiation: absorption and emission of radiation, electric dipole approximation, Einstein's A and B coefficients.

Unit – IV: Scattering Theory (15)

Scattering cross-section, scattering amplitude, partial wave, scattering by central potential: partial wave analysis, optical theorem, scattering by hard sphere, scattering by square well, Breit-Wigner formula, scattering length, expression for phase shifts, integral equation, the Born approximation, scattering by screened Coulomb potential, scattering by Yukawa potential, validity of Born approximation.

Reference Books:

1) Quantum Mechanics: Concepts and Applications, Zettili Nouredine, John Wiley & Sons Ltd., Second Edition (2009).
2)Quantum Mechanics, Aruldhas G, Prentice Hall India Learning Private Lt., 2nd Edition (2009).
3) Introduction to Quantum Mechanics, David J. Griffiths, Pearson Education, 2nd Edition (2015).
4) Quantum Mechanics: Theory and Applications, Ajoy Ghatak and S. Lokanathan, Macmillan Publishers India, Fifth Edition (2004).
5) Modern Quantum Mechanics, J. J. Sakurai and Jim J. Napolitano, Pearson Education India, 2nd Edition, (2013).

M.Sc. (Physics) NEP-Semester-II
Course Code: MSU0325MML936H2
Paper title: Condensed Matter Physics
Total Credits: 4-credits

Condensed Matter Physics

Unit – I: Crystal Physics (15)
Crystalline state of solid, unit cell and Bravais lattice (2D and 3D), bonding of common crystal structure, direction, position, and orientation of planes in crystal, concept of reciprocal lattice, concept of Brillouin zones, closed packed structure, Fourier analysis of the basis (structure factor), Bragg's law, comparison of X-ray, electron and neutron diffraction method.

Unit - II: Crystal Defects (15)
Types of defects, Point defects-Vacancies, Interstitials, impurities, electronic, Line defects-Edge and screw dislocation, Schottky and Frenkel defect Expression for Schottky and Frenkel defects, equilibrium concentration of vacancies, color center, line defect, screw and edge dislocation, Berger's vector and circuit, role of dislocation in plastic deformation and crystal growth, observation of imperfection in the crystals. Frank-Read mechanism. Planer defects, Surface defects- Grain boundaries, Tilt boundaries, Twin boundaries, Effect of Imperfections.

Unit – III: Semiconducting and superconducting properties (15)
Semiconductor: Determination of Band gap energy, direct and indirect band gap, effective mass, intrinsic and extrinsic semiconductors, carrier concentration, Fermi level and conductivity for intrinsic and extrinsic semiconductor, impurity level in doped semiconductor, Hall Effect. Quantum Confinement.
Superconductor: Critical temperature, effect of magnetic field, Meissner effect, type-I and type-II superconductor, London equation, coherence length, Josephson effect (flux quantization), BCS theory, introduction of high Tc superconductor, SQUID, Cooper pairing in superconducting dots.

Unit – IV: Dielectrics and Magnetism (15)
Dielectrics: Polarization mechanism, dielectric constant, Lorenz cavity field, Clausius-Mossotti equation, ferroelectricity and piezoelectricity, type of ferroelectric and piezoelectric.
Magnetism: Classification of magnetic materials, Langevin theory of diamagnetism, paramagnetism and ferromagnetism, theory of diamagnetism- Heisenberg exchange interaction theory (ferro-antiferro and ferrimagnetism), Weiss theory of ferromagnetism. Comparison between dia, para and ferromagnetism, Super-paramagnetism.

Reference Books:

1. Introduction to Solid State Physics Kittel, 8^{th}edn. JohnWiley & Sons. Inc., New York (2019).
2. Solid State Physics by A. J. Dekker, MacMillan India Ltd. (1986).
3. Solid State Physics-N. W. Ashcroft and N. D. Mermin, HRW International edn. (1976).
4. Solid State Physics–S. O. Pillai. New Age International Publication. -2002
4. Solid State Physics-H. C. Gupta-Vikas Publishing House, New Delhi-2002
5. Electronic Properties of Materials - R.E.Humel, 2^{nd}edn.Springer International(1994)

6. Solid State Physics–J. S.Blakemore, 2nd edn. Cambridge University Press (1985)

M.Sc. (Physics) NEP -Semester-II
Course Code: MSU0325MMP936H1
Paper title: Physics LAB-III
Total Credits: 4-credits

Laboratory/ Practical Course- III

1. Fourier analysis.
2. Transmission characteristics of passive filters.
3. I-V characteristics of solar cell.
4. A. C. bridges (Maxwell, Anderson and De-Sauty bridge)
5. Thermal diffusivity of brass.
6. Mutual inductance of given coil.
7. Series & parallel resonant LCR circuits.
8. Young’s modulus of a beam by flexural vibration created by frequency generator.
9. 2D and 3D plots using Mathematica.
10. Band gap energy of semiconductor.
11. Resistivity of given semiconductor sample using four probe method.
12. Thermoelectric Power
13. Magnetic field variation as a function of resonance frequency using ESR.
14. Crystal structure of thin film by using given XRD data.
15. Rydberg constant.
16. Dissociation energy of iodine molecule.
17. Magnetic susceptibility of ferric chloride solution.
18. Plank’s constant using photocell.
19. Numerical solutions of simple first order differential equation using Python (Euler and Runge Kutta 4th order method)
20. Plotting simple functions using Python.
21. Plotting of simple graphs using origin software.
22. Crystallite size by Debye- Scherrer Formula ($D=0.9\lambda/\beta \cos\theta$).

M.Sc. (Physics)NEP- Semester-II
Course Code: MSU0325MMP936H2
Paper title: Physics LAB-IV
Total Credits: 2-credits

Laboratory/ Practical Course- IV

(Seminar & certified seminar report 1-credits +Tutorials on practical-1-credits)

Total Credits: 2-credits

M.Sc. (Physics) NEP-Semester-II
Course Code: MSU0325FPP936H
Paper title: Field Project
Total Credits: 4-credits

On Job Training/ Field Project

On job training/Field project at CFC/PIFC/Research Institutes/Industries etc. for students of M. Sc. Physics at university department and affiliated colleges.

Total Credits: 4-credits

Elective Paper

(Choose any one from Specialization)

Sr. No.	**Course Code**	**Paper Title**
1	SSP-2	Semiconductor Devices (4 credits)
2	SP-2	Magnetospheric Plasma Dynamics (4 credits)
3	TH-2	Interaction of Electromagnetic Waves with Electron Beams and Plasmas (4-credits)
4	MO-2	Molecular Spectroscopy (4-credits)
5	ES-2	Energy conversion devices (4 credits)
6	MS-2	Properties of Materials (4 credits)

M.Sc. (Physics) NEP Semester-II
Course Code: MSU0325MEL936H1
Paper Title: Semiconductor Devices
Total Credits: 4-credits

(Solid State Physics-2)
Semiconductor Devices

Unit I: Transistors and Microwave Devices: **(15)**

Bipolar junction transistor (BJT), Frequency response and switching, of BJT, Base Narrowing, Ebers-Moll Model, Gummel–Poon Model, Kirk Effect, Field effect transistor (FET), JFET, MOSFET, MESFET, Tunnel diode, Transferred electron devices and Gunn diode, Avalanche transit time diode and, IMPATT diode.

Unit II: Photonic Devices: **(15)**

Optical absorption, Radiative and non-radiative transitions, Light emitting diodes, Organic LED, Infrared LED, Photo detector, Photoconductor, Photodiode, Solar cells, Semiconductor Lasers.

Unit III: Memory Devices: **(15)**

Number system and its conversion to binary number, Semiconducting memories, Memory organization, Read and Write operation, expanding memory size, Classification and characteristics of memories, Static and dynamic RAM, Charge couple memory (CCD) devices, Magnetic, optical, ferroelectric, Spintronic and other memory based devices.

Unit IV: Other electronic Devices: **(15)**

Magneto-optic and acousto-optic effects, Material's properties related to get these effects, Piezoelectric, Electrostrictive and Magnetostrictive effects, Sensors, and actuator devices.

Reference Books:

1) Semiconductor devices: Physics and Technology 2nd Edition, S. M. Sze
2) Modern Digital Electronics, R. P. Jain
3) Introduction to Semiconductor devices by M. S. Tyagi
4) Optical electronics by Ajoy Ghatak and K. Thyagrajan, Cambridge University Press.

M.Sc. (Physics) NEP Semester-II
Course Code: MSU0325MEL936H2
Paper title: Magnetospheric Plasma Dynamics
Total Credits: 4-credits

(Space Physics-2)
Magnetospheric Plasma Dynamics

Unit-I: The Earth's Magnetic Field and Magnetosphere (15)
The Earth's Magnetic Field and Magnetosphere, The magnetopause, the geomagnetic tail, magnetic reconnection-concept, magnetic reconnection and Magnetospheric dynamics, fluid description of reconnection, particle description of reconnection.

Unit-II: Reconnection at Magnetopause (15)
Magnetopause boundary layers, signatures of magnetopause reconnections, patchy, unsteady reconnection, reconnection, and the plasma-sheet boundary layer.

Unit-III: Magnetospheric configuration (15)
Magnetic field configuration of the earth's magnetosphere, plasma in the earth's middle and inner magnetosphere-plasma in the Earth's near magnetotail, geostationary orbit region, trapped radiation belt and the ring-current particles, plasma sphere, electric fields and Magnetospheric convection, ionosphere-magnetosphere coupling, Ionospheric currents, loss of Magnetospheric particles in earth's atmosphere.

Unit-IV: Geomagnetic storms (15)
Geomagnetic storms, geomagnetic indices, effects of geomagnetic storms on the Earth's upper atmosphere and ionosphere-electric field and neutral wind disturbances.

Reference Books:
1. Introduction to Space Physics by Margaret G. Kivelson (Editor), Christopher T. Russell (Editor)
2. The Earth's Ionosphere-Plasma Physics and Electrodynamics, Second Edition, Michael C. Kelley, Academic Press, Elsevier
3. An introduction to the ionosphere and magnetosphere. J. A. Ratcliffe, Cambridge University Press, 1972,
4. Ionospheres: Physics, Plasma Physics, and Chemistry by Robert Schunk Andrew Nagy
5. Elements of space physics by R. P. Singhal
6. Advanced Magnetohydrodynamics: With Applications to Laboratory and Astrophysical Plasmas by J. P. Goedbloed, Rony Keppens, Stefaan Poedts
7. Source book on space science by S. Glasstone
8. The Upper Atmosphere Data Analysis and Interpretation, W. Dieminger G.K.Hartmann R. Leitinger (Eds.), Springer- 1996, ISBN-13 :978-3-642-78719-5

M.Sc. (Physics) NEP Semester-II
Paper Code: MSU0325MEL936H3
Paper title: Interaction of Electromagnetic Waves with Electron Beams and Plasmas
Total Credits: 4-credits

(Theoretical Physics-2)
Interaction of Electromagnetic Waves with Electron Beams and Plasmas

Unit 1: Basic equations and properties of linear Waves (15)
Introduction, Maxwell Equations, Dispersion Relation, Energy Density and Energy flow, The Kinetic equation, Fluid equations, Plasma response to an electromagnetic wave, Diffraction divergence, Dispersion broadening.

Unit 2: Resonance absorption, plasma wave excitation, coherent emission of radiation (15)
Current Density, Coupled Mode Equations, Mode conversion, Excitation of a Langmuir wave, Electron Acceleration in a Langmuir wave.

Unit 3: Self-focussing and filamentation, parametric instabilities in a homogeneous plasma (15)
Phase coherence and Bunching, Cerenkov FEL, Free Electron Laser (Till Growth rate), Self-focusing, Filamentation Instability a Harmonic oscillator, Parametric oscillator with two degrees of freedom, Parametric coupling in a Plasma.

Unit 4: A nonlinear Schrodinger equation and parametric instabilities in an inhomogeneous plasma (15)
Basic equation, Stationary solution, Instability of an Envelope Soliton, Criterion for Collapse, WKB Solution, Raman Side scattering, Brillouin Side scattering,

Reference book:
1. Interaction of Electromagnetic waves with electron beams and Plasmas, World Scientific, 1994
By C S Liu and V S Tripathi,

M.Sc. (Physics) NEP Semester-II
Course Code: MSU0325MEL936H4
Paper Title: Molecular spectroscopy
Total Credits: 4-credits

(**Modern Optics-2)**
Molecular spectroscopy

Unit I: Basics of molecular spectroscopy (15)
Molecular Structure and Molecular Spectra: Covalent, ionic and Vander Waal bonding, Valence bond and Molecular orbital approach for molecular bonding, Crystal Field Theory, electronic structure of homo nuclear diatomic molecules, pairing and valency, hetero nuclear diatomic molecules,, Electronic spectra of diatomic molecules – Born-Oppenheimer approximation, Electronic structure of polyatomic molecules: hybridization-hybrid orbital's, bonding in hydrocarbons.

Unit II: Absorption and Luminescence spectroscopy (15)
UV/Visible Molecular Absorption Spectroscopy: Optical absorption: Free carrier absorption-optical transition between bands-direct, and indirect-excitons, Beer's law, and its limitations. Instrumentation: sources; single and double beam spectrometers; Solvent-effects; Bathochromic and Hypochromic shifts; Assignment of σ and π transitions.
Molecular Luminescence Spectroscopy: Luminescence in crystal - excitation and emission – decay mechanism, Fluorescence and Phosphorescence (with energy level diagram); Transition types; quantum efficiency (yield). Instruments: Fluoro meters and Spectro fluoro meters; lifetime measurements, Radiative and Natural lifetime, Decay curves, Applications.

Unit III: Vibrational Spectroscopy (15)
The vibrations of polyatomic molecules: Infrared Absorption process, Modes of stretching and bending, bond properties and absorption trends, vibrational coarse structure – progressions. Intensity of vibrational transitions – the Franck-Condon principle, Molecular vibrations and Group frequencies,
Infrared Spectrometry: IR sources; transducers, Instruments: Dispersive and FT-based spectrometers; sample handling. Interpretation of spectra-structure correlations.
Raman Spectroscopy: Origin of Raman scattering (qualitative); activity and intensity of Raman bands; depolarization ratio. Pure rotational Raman spectra, Vibrational Raman spectra, Polarization of light and the Raman effect. Instrumentation; sources; dispersive and FT-based Raman spectrometers; sample handling. Applications. Comparison of vibrational Raman and infrared spectra.

Unit IV: Nuclear spectroscopy (15)
Nuclear Magnetic Resonance (NMR) Spectroscopy: Nuclear Magnetic Resonance: Principles, Classical treatment of NMR (Bloch equations), Interaction between nuclear spin and magnetic moment; resonance condition; population of energy levels. Relaxation processes: spin-lattice and spin-spin relaxations (qualitative). The chemical shift and its correlation with molecular structure. Typical NMR spectrometers (cw/FT); sample handling, applications of NMR.
Photoelectron spectroscopy Types - UPS and XPS. Experimental method for UPS and XPS. Ionization processes and Koopmans' theorem. Interpretation of UP and XP spectra with Applications.

Auger electron and X-ray fluorescence spectroscopy: experimental methods and processes.

Reference Books

1) Fundamentals of Molecular Spectroscopy, 4thEdition. – C.N. Banwell, Tata Mac Graw Hill (2008).
2) Molecular structure and spectroscopy-2nd Edition -G. Aruldhas, Prentice Hall of India, (2002)
3) Introduction to Spectroscopy, 5th Edition- Pavia, Lampman, Kriz, and Vyvyan, Cengage Learning, USA,
4) Modern Spectroscopy (4th Ed): J.M. Hollas, John Wiley & Sons Ltd, UK (2004)
5) Principles of Instrumental Analysis (5th ed): D. A. Skogg, F. J. Holler & T. A. Nieman, Harcourt Asia Pte. Ltd. (1998)

5) Introduction to Molecular Spectroscopy – G.M. Barrow, MacGraw Hill (1962).
6) Molecular Spectra and molecular structure I, II, III, G. Herzberg, D. Van Nostrand Company Inc., 1963
7) Physics of Atoms and Molecules - B. H. Bransden and C. J. Joachain, Pearson; 2008.
8) A. H. Kitai; Solid State Luminescence; Chapman and Hall, London; 1993.
9) Luminescence of Solids edited by D. R. Vij, Plenum Press, New York, 1998.

M.Sc. (Physics) NEP Semester-II
Course Code: MSU0325MEL936H5
Paper title: Renewable Energy Resources-II
Total Credits: 4-credits

(Energy Studies-2)
Renewable Energy Resources-II

Unit I: Wind Energy **(15)**
Global circulation, Forces influencing wind, Local Wind systems, Aerodynamics of windmill: Maximum power, and Forces on the Blades and thrust on turbines; Betz limit, coefficient of power. Wind measurements: anemometer and wind vane, Wind data collection and field estimation of wind energy, Site selection, Basic components of wind mill, Wind turbines types: Vertical Axis Type, Horizontal Axis, Constant Speed Constant Frequency, Variable speed Variable Frequency, Up Wind, Down Wind, Stall Control, Pitch Control, Gear Coupled Generator type, Direct Generator Drive /PMG/Rotor Excited Sync Generator, Wind energy farm, Hybrid wind energy systems: wind + PV; wind energy and environment. The present Indian Scenario.

Unit II Biomass Energy and conversion processes **(15)**
Nature of Biomass as a fuel, CO_2 fixation potential, Biomass energy conversion processes, Direct combustion: heat of combustion, combustion with improved Chulha and cyclone furnace; incineration. Dry chemical conversion processes: pyrolysis, gasification, types of gasification: updraft, downdraft, fluidized bed, Biochemical conversion process: anaerobic digestion, biogas production mechanism and technology, types of digesters, design of biogas plants, Factors affecting the process. Ethanol production.

Unit-III Geothermal energy **(15)**
Geothermal Energy: Availability of Geothermal Energy-size and Distribution, Recovery of Geothermal Energy, Various Types of Systems to use Geothermal Energy, Direct heat applications, Power Generation using Geothermal Heat, Sustainability of Geothermal Source, Status of Geothermal Technology, Economics of Geothermal Energy.

Unit-IV Tide and Wave Energy **(15)**
Tidal Energy: Introduction, Origin and Nature of Tidal Energy, Advantages of Tidal Energy, Limitations of Tidal Energy, Tidal Energy Plant, Energy Potential Estimation, Ocean Tidal Energy Conversion Schemes (Single Basin: Single Effect, Single Basin: Double Effect, Two Basin: Linked Basin, Two Basin: Paired Basin and Tidal Flow or Tidal Current), Global Scenario of Tidal Energy, Tidal Power Development in India ,Wave Energy: Introduction, Advantages and Disadvantages of Wave Energy, Power in Waves, Wave Energy Technology (Heaving Float Type Devices, Pitching Type Devices, Heaving and Pitching Float Type Devices, Oscillating Water Column Type Devices and Surge Devices), Global Scenario of Wave Energy, Tidal Power Development in India, Ocean **Thermal Energy:** Introduction, Origin of Ocean Thermal Energy Conversion and Efficiency, Ocean Thermal Energy Conversion Technology (Open Cycle/Claude Cycle Plant, Closed Cycle/Anderson Cycle Plant, Advantages and Disadvantages of Ocean Thermal Energy Conversion, Global and Indian Status of Ocean Thermal Energy Conversion.

Reference Books

1) Sorensen B., “Renewable Energy,” Second Edition, Academic Press, 2000.
2) Erich Hau, “Wind Turbines- Fundamentals: Technologies, Application, and Economics.” Springer – Verlag Berlin -Heidelbeg, 2000.
3) Wind energy Conversion Systems – Freris L.L. (Prentice Hall1990)
4) Wind Turbine Technology: Fundamental concepts of wind turbine technology Spera D.A. (ASME Press, NY, 1994)
5) Wind Energy Systems – G. L. Johnson (Prentice Hall, 1985)
6) Wind Energy Explained – J. F. Manwell, J.G. McGowan, and A.L. Rogers (John Wiley & Sons Ltd.)
7) Biomass, Energy and Environment- N.H. Ravindranath and D.O Hall, Oxford University Press.
8) Biomass Energy- S.H. Pawar, L.J. Bhosale, A.B. Sabale and S.K. Goel.
9) Advances in Energy systems and technology- Peter Auer.

M.Sc. (Physics) NEP Semester-II
Course Code: MSU0325MEL936H6
Paper title: Properties of Materials
Total Credits: 4-credits

(Material Science -2)
Properties of Materials

Unit I: Physical and mechanical properties of the materials (15)
Stress Versus Strain (metals, ceramics and glasses, polymers), Elastic Deformation, Plastic Deformation, Hardness, Creep and Stress Relaxation, Viscoelastic Deformation.

Unit II: Thermal Properties (15)
Thermal expansion, Thermal conductivity, Thermal shock, Specific heat capacity, The specific heat curve and transformations, Free energy of transformation.

Unit III: Electric and magnetic properties (15)
Electric properties: Electric conductivity, Semiconductors, Hall Effect, Superconductivity, Oxide superconductors. Magnetic properties: Magnetic susceptibility, Diamagnetism and paramagnetism, Ferromagnetism, Magnetic alloys, Anti-ferromagnetism and ferrimagnetism, Dielectric materials, Polarization, Capacitors and insulators, Piezoelectric materials, Pyroelectric and ferroelectric materials.

Unit IV: Optical Properties (15)
Optically active materials, Reflection, absorption and transmission effects, optical fibers, ceramic windows, electro-optic ceramics.

References:
1) Physical metallurgy. – R. W. Cahn, II Edition, North Holland, Amsterdam (1970)
2) Physical metallurgy. – R. W. Cahn and P. Haasen, III Edition, North Holland, Amsterdam, (1983)
3) Physical metallurgy principles – R.E. Read-Hill, Affiliated East West Press Ltd.,New Delhi, (1970) 4) 4) Modern physical metallurgy – R.E. Smallman, Butterworths, London (1970)
5) Physical properties of glass - D. G. Holloway Wykeham publications, London (1973)
6) An introduction to metallurgy – A.H. Cottrell, Edward Arnold, London (1967)
7) M.A. Wahab; Solid State Physics: Structure and Properties of Materials, Alpha Science International (2005)
8) K. H. J. Buschow& F. R. de Boer: Physics of Magnetism and Magnetic Materials.
9) S.O. Pillai; Solid State Physics, 6th Ed., New Age International (p) Ltd publishers, (2005)
10) Charles Kittle; Introduction to Solid State Physics, 7th Edition, John Wiley & Sons

M. Sc. - II
(Semester-III)

M.Sc. (Physics) NEP Semester-III
Course Code: MSU0325MML916I1
Paper title: Statistical Mechanics
Total Credits: 4-credits

Statistical Mechanics

Unit I: Contact between Statistics and Thermodynamics: (15)
Fundamental postulate of equilibrium statistical mechanics, Basic concepts – Phase space, ensemble, a priori probability, Liouville's theorem (Revision). Fluctuations of physical quantities, Statistical Equilibrium, Thermodynamic Laws and their consequences (in brief), Thermodynamic Functions – Entropy, Free energy, Internal Energy, Enthalpy (definitions), Maxwell's Equations (only equations), Contact between statistics and thermodynamics – Entropy in terms of microstates, Gibb's paradox, Sackkur-Tetrode formula.

Unit II: Classical Statistical Mechanics: (15)
Micro canonical Ensemble– Micro canonical distribution, Entropy and specific heat of a perfect gas, Entropy and probability distribution, Canonical Ensemble– Canonical Distribution, partition function, Calculation of free energy of an ideal gas, Thermodynamic Functions, Energy fluctuations. Grand Canonical Ensemble– Grand Canonical distribution, Thermodynamic Functions,Number and Energy fluctuations.

Unit III: Quantum Statistical Mechanics: (15)
Quantum Statistics: Distinction between MB, BE and FD distributions, Quantum distribution functions –Bosons and Fermions and their distribution functions, Boltzmann limit of quantum gases, Partition function, Ideal Bose gas, Bose -Einstein Condensation, Specific heat of solids (Einstein and Debye models) Phonon gas, Liquid He4: Second Sound, Ideal Fermi gas: Weakly and strongly degenerate, Fermi temperature, Fermi velocity of a particle of a degenerate gas , Electron gas: Free electron theory ofmetals, Pauli paramagnetism, white dwarfs, *Brownian motion*: Einstein-Smoluchowski theory, Langevin theory, Approach to equilibrium: Fokker-Planck equation, the fluctuation-dissipation theorem.

Unit IV: Phase Transitions, and Critical Phenomenon (15)
Phase Transitions, Conditions for phase equilibrium, First order Phase Transition: Clausius - Clayperon equation, Second order phase transition, The critical indices, Weakly Interacting Gases, Weiss Molecular theory of paramagnetism, The Ising Model of a Ferromagnetism

Reference books:
1) Statistical Mechanics Theory and Applications, S K Sinha, Tata McGraw-Hill, (1990).
2) Introduction to Statistical mechanics, B B Laud, Macmillan, N Delhi, (1981).
3) Statistical Mechanics by R K Pathria, Pergamon press (1972).
4) Statistical and thermal Physics F Reif, McGraw-Hill (1965).
5) Statistical Physics, L D Landau, and E M Lifshitz, Pergamon press (1958).

M.Sc. (Physics) NEP Semester-III
Course Code: MSU0325MML916I2
Paper title: Atomic & Molecular Physics
Total Credits: 4-credits

Atomic and Molecular Physics

Unit - I: Atomic Spectra **(**15)
Quantum states of an electron in an atom, electron spin, spectrum of helium and alkali atom. Relativistic corrections for energy levels of hydrogen atom, ll-coupling, ss-coupling, LS or Russell - Saunder's coupling; the Pauli exclusion principle, Coupling schemes for two electrons, Γ- factors for LS coupling, Lande interval rule, jj coupling, branching rules, selection rules, Intensity relations.

Unit - II: Effect of magnetic and electric field on atomic spectra **(**15)
The magnetic moment of the atom, Zeeman effect for two-electrons, Intensity rules for Zeeman effect, Paschen-Back effect for two electrons, Stark effect of hydrogen, weak field Stark effect in hydrogen, strong field Stark effect in hydrogen, origin of hyperfine structure, Inner shell vacancy, X-ray and Auger transitions, Compton effect.

Unit - III: Molecular spectra **(**15)
Molecular physics – covalent, ionic and Vander Waal's interaction, Classification of molecules: linear, symmetric tops, spherical tops, asymmetric tops; rotational spectra: the rigid diatomic molecule, the non-rigid rotator, spectrum of a non-rigid rotator, techniques and instrumentation of microwave spectroscopy, chemical analysis by microwave spectroscopy, the vibrating diatomic molecule: the energy of a diatomic molecule, the simple harmonic oscillator, the anharmonic oscillator, the diatomic vibrating-rotator, vibrational rotational spectra, techniques and instrumentation of infra-red spectroscopy, chemical analysis by infra-red spectroscopy.

Unit - IV: Electronic, Nuclear and Raman spectra **(**15)
Revision on electronic spectra of diatomic molecules, electron spins resonance, nuclear magnetic resonance, chemical shift. Frank-Condon principle, dissociation energy and dissociation products, rotational fine structure of electronic-vibration, transitions. Born-Oppenheimer approximation, separation of electronic and nuclear motions in molecules, band structures of molecular spectra. Raman spectra: Pure rotational Raman spectra, vibrational Raman spectra, polarization of light and Raman effect, techniques, and instrumentation of Raman spectroscopy.

Reference books:

1) Introduction to Atomic Spectra – H.E. White, Mac-Graw Hill (1934).
2) Fundamentals of Molecular Spectroscopy, 4th Edition. – C.N. Banwell, Tata MacGraw Hill (2008).
3) Molecular Structure and Spectroscopy, G. Aruldhas, PHI Learning Pvt. Ltd. Spectra of diatomic Molecules, Vol. I – G. Herzberg, N.J.D. van Nostrand (1950).
4) Spectroscopy, Vol. I, II and III – B.P. Straughan and S. Walker, Chapman, and Hall (1976).
5) Introduction to Molecular Spectroscopy – G.M. Barrow, McGraw Hill (1962).

6) Molecular Spectroscopy – J.M. Brown, Oxford University Press (1998).

M.Sc. (Physics) NEP Semester-III
Course Code: MSU0325MMP916I1 (SSP- V &VI)
Paper title: SOLID STATE PHYSICS LAB –V & VI
Total Credits: 4-credits

Laboratory/ Practical Course-SSP-V
(Solid State Physics Lab –V)

List of Experiments
Group I:

[1] Thin film deposition by SILAR method
[2] Thin film deposition by electro-deposition method
[3] Thin film deposition by hydrothermal method
[4] Thin film deposition by reflux method
[5] Thin film deposition by dip-coating method
[6] Thin film deposition by CBD method
[7] Microwave assisted synthesis of thin film
[8] Thin film deposition by spray pyrolysis method

Group II:

[9] Rietveld method of structure refinement
[10] Calculation of XRD peak positions and intensities
[11] Thickness measurement of thin film by transmittance spectroscopy
[12] Electrical resistivity of thin film by 2 probe method
[13] Thermoelectric power of thin film
[14] Contact angle measurement of thin film
[15] Determination of band gap energy of thin film
[16] Measurement of dielectric constant

Laboratory/ Practical Course-SSP-VI
(Seminar & certified seminar report 1-credits +Tutorials on practical-1-credits)
Total Credits: 2-credits

Solid State Physics Project Work - I (4 credits)

M.Sc. (Physics) NEP Semester-III
Course Code: MSU0325MMP916I1 (MO- V &VI)
Paper title: Modern Optics LAB –V & VI
Total Credits: 4-credits

Laboratory/ Practical Course - MO-V
(Modern Optics Lab-V)

List of Experiments

1. Michelson's Interferometer
2. Talbots Bands
3. Calibration of Spectrograph
4. Laser beam Divergence
5. Calibration of CD spectrograph
6. Determination of wavelength of light by grating
7. Production and analysis of polarized light with the help of He-Ne laser
8. Iron Arc spectra
9. Copper Arc spectra
10. Z-scan technique
11. Recording and reconstruction of Hologram
12. Ellipsometry
13. Zeeman Effect

   *Depending on availability of new experimental kits, few new experiments will be added to this list.

Tutorial: There will be a tutorial in practical examination based on these experiments.

Laboratory/ Practical Course-MO-VI
(Seminar & certified seminar report 1-credits +Tutorials on practical-1-credits)
Total Credits: 2-credits

Modern Optics Project Work - I (4 credits)

M.Sc. (Physics) NEP Semester-III
Course Code: MSU0325MMP916I1 (SP- V &VI)
Paper title: Space Physics LAB –V & VI
Total Credits: 4-credits

Laboratory/ Practical Course-SP-V
(Space Physics Lab - V)

List of Experiments:
1) Introduction to Python
2) Introduction to MATLAB
3) Proton precession magnetometer
4) Amplitude Modulation
5) Variable Attenuator
6) NavIC-IRNSS: Data Mining and analysis using MATLAB
7) Total electron content by NavIC-IRNSS
8) Solar Data Analysis-I (Electromagnetic)
9) Solar Data Analysis-II (Energetic Particle)
10) Frequency characteristic of Ku-band
11) Beam width of parabolic dish antenna
12) Mounting of Telescope
13) Solar Data Analysis-III (Sunspots)
14) Designing of Yagi Antenna
15) Study of Leafy Vegetation
16) Beam width of Yagi Antenna & field strength
17) X-band characteristics of patch antenna
18) Solar Data Analysis-IV (Coronal Holes and Solar wind)

Laboratory/ Practical Course-SP-VI
(Seminar & certified seminar report 1-credits +Tutorials on practical-1-credits)
Total Credits: 2-credits

Space Physics Project Work - I (4 credits)

M.Sc. (Physics) NEP Semester-III
Course Code: MSU0325MMP916I1 (THP- V &VI)
Paper title: Theoretical Physics LAB –V & VI
Total Credits: 4-credits

Laboratory/ Practical Course-THP-V
(Theoretical Physics Lab-V)

List of Experiments:
Introduction to Mathematica for Scientists and Engineers (Notebook form in Mathematica Tutorials) (IMSE)
1. IMSE Ch1: Introduction
2. IMSE Ch2: Functions
3. IMSE Ch3: Symbolic Manipulations
4. IMSE Ch4: Plots
5. IMSE Ch5: Lists, Arrays

Tutorials
Tutorials from Schaum's Outlines: Mathematica (Eugene Don)
1. Getting Acquainted
2. Basic Concepts
3. Lists
4. Two-dimensional Graphics
5. Three-dimensional Graphics
3. Assignments

Laboratory/ Practical Course-THP-VI
(Seminar & certified seminar report 1-credits +Tutorials on practical-1-credits)
Total Credits: 2-credits

Theoretical Physics Project Work - I (4 credits)

M.Sc. (Physics) NEP Semester-III
Course Code: MSU0325MMP916I1 (ES- V &VI)
Paper title: Energy Studies LAB –V & VI
Total Credits: 4-credits

Laboratory/ Practical Course - ES-V
(Energy Studies Lab-V)

List of Experiments:
1. Oxygen bomb Calorimeter
2. Wood Pyrolysis-I
3. Wood Pyrolysis-II
4. Powdery Biomass Gasifier
5. Microsoft Excel
6. Current Density
7. Solar Cell Characteristics
8. Sunshine Recorder
9. Pyranometer
10. Wind Data analysis
11. Air mass Ratio
12. Underground Resistivity measurement
13. Heat pipe
14. Biogas Plant
15. Vacuum Deposition System
16. Spray Pyrolysis System

Laboratory/ Practical Course-ES-VI
(Seminar & certified seminar report 1-credits +Tutorials on practical-1-credits)
Total Credits: 2-credits

Energy Studies Project Work - I (4 credits)

M.Sc. (Physics) NEP Semester-III
Course Code: MSU0325MMP916I1 (MS- V &VI)
Paper title: Material Science LAB –V & VI (4+2), **Project work (4 credits**)
Total Credits: 10-credits

Laboratory/ Practical Course - MS- V
(Materials Science Lab-V) (4 credits)

List of Experiments:

1. Cooling curves
2. Stress-Strain curves
3. Average grain diameter by SEM
4. Laue diffraction
5. Crystal structure
6. Preparation of ferrite
7. Spectrometry of colored solutions
8. Crystal structure of thin film
9. Crystal growth from solution
10. Ionic conductivity

Laboratory/ Practical Course-MS-VI

(Seminar & certified seminar report 1-credits +Tutorials on practical-1-credits)

Total Credits: 2-credits

Material Science Project Work - I (4 credits)

Elective Paper

Choose any on elective paper from specialization)

Sr. No.	Course Code	Paper Title
1	SSP-3	Thin solid films: Deposition and properties (4 credits)
2	SP-3	Ionospheric Physics and Space Weather (4 credits)
3	TH-3	Introduction to General Relativity (4 credits)
4	MO-3	Nonlinear Optics and Fiber Optics (4-credits)
5	ES-3	Solar Photovoltaic and Thermal Systems (4 credits)
6	MS-3	Special Materials (4 credits)

M.Sc. (Physics) NEP-Semester-III
Course Code: MSU0325MEL916I1
Paper title: Thin solid films: Deposition and properties
Total Credits: 4-credits

(Solid State Physics- 3)
Thin solid films: Deposition and properties

Unit 1: Physical methods of thin film deposition (15)
Vacuum deposition apparatus: Vacuum systems, substrate deposition technology, substrate materials, Thermal Evaporation methods: Resistive heating, Flash evaporation, Arc evaporation, laser evaporation, electron bombardment heating, Sputtering: sputtering variants, glow discharge sputtering, Magnetic field assisted (Triode) sputtering, RF Sputtering, Ion beam sputtering, sputtering of multi- component materials.

Unit 2: Chemical methods (15)
Chemical vapor deposition: Common CVD reactions, Methods of film preparation, laser CVD, Photochemical CVD, Plasma enhanced CVD, Chemical bath deposition, Electro deposition, Spray pyrolysis, successive ionic layer adsorption reaction method (SILAR) method, Sol-gel method, Hydrothermal method.

Unit 3: Nucleation growth processes and thickness measurement (15)
Condensation process, Langmuir-Frenkel theory of condensation, Theory of nucleation and growth process, Thickness measurements: Electrical methods, Microbalance monitors, mechanical method, radiation absorption and radiation emission methods, optical interference methods: photometric method, spectrometric method, interference fringes, X-ray interference fringes.

Unit 4: Properties and characterization of thin films (15)
Mechanical properties of thin films: Introduction to elasticity, plasticity, and mechanical behavior, Electrical and magnetic properties of thin films, Optical properties of thin films, Structural characterization: X-ray diffraction, Scanning electron microscopy, Transmission electron spectroscopy, chemical characterization: X-ray Energy Dispersive Analysis (EDX), X-ray photoelectron spectroscopy (XPS).

Reference Books

1. Thin Film Phenomena by K L Chopra McGraw -Hill Book Company, NY 1969
2. The Materials Science of Thin Films by Milton Ohring, Academic Press, (1992)
3. Properties of Thin Films by Joy George, Marcel, and Decker, (1992)
4. Physics of Thin Films by Ludmila Eckertová, Springer (1986)
5. Thin Film Technology by O S Heavens, Methuen young books (1970)
6. Solid State Physics by N.W. Ashcroft, N. D. Mermin, Harcourt College Publishers (1976)
7. Chemical Solution Deposition of Semiconductor Films by G. Hodes, Marcel Dekker Inc. (2002)

M.Sc. (Physics) NEP Semester-III
Course Code: MSU0325MEL916I2
Paper title: Ionospheric Physics and Space Weather
Total Credits: 4-credits

(Space Physics-3)
Ionospheric Physics and Space Weather

Unit-I: Physical and Chemical process in Atmosphere (15)
Pressures, radiative heating-solar and planetary radiation, radiation trapping-greenhouse effect diurnal and seasonal variations, temperature profiles-troposphere, stratosphere, mesosphere, thermosphere, vertical transport, ion chemistry in the atmosphere, ionization mechanisms, f-region processes, E-region processes, D-region processes.

Unit-II: Ionosphere (15)
Structure of the Neutral Atmosphere and the Main Ionosphere, Formation of the ionosphere, photo-ionization and the Chapman production function, ionization by energetic particles, ion loss mechanisms, determination of ionospheric density from production and loss rates, the Earth's ionosphere, high-speed outflow, conductivity, and current systems.

Unit-IIII: Implications of Space weather effects (15)
Electrical charges in the atmosphere, aurora, geomagnetic fluctuations, radio propagation, Effect on satellite electronics, satellite charging, satellite drag, heating of the neutral atmosphere, Effect on radio wave propagation, effect on communications and navigational outages

Unit-IV: Global Navigation Satellite System (GNSS) (15)
GNSS Systems, GPS (United States), GLONASS (Russia), Galileo (European Union), BeiDou (China), IRNSS (India), QZSS (Japan),GNSS Architecture, Space Segment, Control Segment, User Segment, GNSS Signals, GNSS Positioning, GNSS User Equipment, GNSS Antennas, GNSS Receivers, GNSS Augmentation

Reference Books:

1. Introduction to Space Physics by Margaret G. Kivelson (Editor), Christopher T. Russell (Editor)
2. Space Physics: An Introduction, by C. T. Russell, J. G. Luhmann, et al. Cambridge University Press; Har/Psc edition (August 18, 2016)
3. Chemistry of Atmospheres: An Introduction to the Chemistry of the Atmospheres of Earth, the Planets, and their Satellites 3rd Edition, Oxford University Press; 3 edition (March 30, 2000)
4. Elements of space physics by R. P. Singhal
5. The Upper Atmosphere Data Analysis and Interpretation, W. Dieminger G.K. Hartmann R. Leitinger (Eds.), Springer- 1996, ISBN-13 :978-3-642-78719-5
6. An Introduction to GNSS GPS, GLONASS, BeiDou, Galileo and other Global Navigation Satellite Systems, second edition, Published by NovAtel Inc. ISBN: 978-0-9813754-0-3

M.Sc. (Physics) NEP Semester-III
Course Code: MSU0325MEL916I3
Paper title: Introduction to General Relativity
Total Credits: 4-credits

(Theoretical Physics -3)
Introduction to General Relativity

Unit-I: Special Relativity (15)
Fundamental principles of STR, Inertial observer, Space-time diagrams, Construction of the coordinates used by another observer, Invariance of interval, Invariance of hyperbolae, The Lorentz transformation, The velocity composition law, paradoxes, and physical intuition.

Unit-II: Vectors and tensors in special relativity (15)
Definition of a vector, Vector algebra, The four-velocity, The four momentum, Scalar product, Applications. The metric tensor, Definition of tensors the (0, 1) tensors: one-forms, The (0,2) tensors, Metric as a mapping of vectors into one-forms, (M, N) tensors, Index raising and lowering, tensor differentiation.

Unit-III: Curvature and manifolds (15)
Relation between gravitation and curvature, Tensor algebra and calculus in polar coordinates, Christoffel symbol and the metric, Non-coordinate bases. Differentiable manifolds and tensors, Riemannian manifolds, Covariant differentiation, Parallel transport, geodesics and curvature, The curvature tensor, Bianchi identities: Ricci and Einstein tensors.

Unit-IV: Physics in curved space-time, Einstein field equations and stellar solutions (15)
The transition from differential geometry to gravity, Physics in slightly curved space-times, Curved intuition, Conserved quantities. Purpose and justification of the field equations, Einstein's equations, Einstein's equations for weak-gravitational fields, Newtonian gravitational fields. Coordinates for spherically symmetric space-times, Static spherically symmetric space-times, Static perfect fluid Einstein equations, The exterior geometry, The interior structure of the star, Exact interior solutions, Realistic stars, and gravitational collapse.

Reference Books:
1) A First Course in General Relativity, Bernard Schutz, Cambridge Press
2) Spacetime And Geometry, Sean Carroll, Pearson Education
3) General relativity and Cosmology, Jayant V. Narlikar, Macmillan Press
4) Gravity, James Hartle, Pearson Education

M.Sc. (Physics) NEP Semester-III
Paper Code: MSU0325MEL916I4
Paper title: Nonlinear Optics and Fiber Optics
Total Credits: 4-credits

(Modern Optics-3)
Nonlinear Optics and Fiber Optics

Unit – I: Nonlinear Medium: (15)

Maxwell's equations in nonlinear media, Nonlinear polarization and susceptibilities, measurement of non-linear optical susceptibilities, classical model of nonlinearity: anharmonic oscillator and free electron gas. Electro-optical and magneto-optical effects, Optical rectification, Induced magnetization.

Unit – II: Nonlinear Phenomena and Applications (15)

Second Harmonic Generations – Polarization waves, phase matching conditions, coherence length, coupled wave equations, Parametric amplification and oscillation, frequency tuning of parametric oscillator, Optical phase conjugation, Self – Self focusing of laser beam – physical description, elementary analysis, Parabolic wave equation and solution for slowly conversing/ diverging beam. Tunable coherence radiation source, Stimulated Raman scattering as spectroscopy tool.

Unit – III: Optical fibers (15)

Basic characteristics of optical fibers, Physical description, numerical aperture, attenuation in optical fibers, pulse dispersion, Loss mechanism, step index and graded index fibers, material and fabrication, light propagation (ray theory), Transmission losses, Nonlinear Optical effects in fiber, Measurement methods in optical fiber

Unit – IV: Optical Fiber Waveguide and Applications: (15)

E.M. theory of propagation, Modes of fiber, Mode's cut-off, Single and multimode fibers, Modal analysis of step index and graded index fibers, Signal distortion – inter modal, material and wave guide dispersion, waveguide dispersion, Sources and Detectors for optical fiber communication, Optical fibers in Telecommunications and Sensor systems.

Reference Books:

1. Y.R. Shen, The Principles of Nonlinear Optics, Wiley Inter Science, (1984).
2.A.K. Ghatak& K. Thyagarajan, Introduction to Fiber Optics, Cambridge University Press (1999).
3. A.K. Ghatak and K. Thyagarajan, Optical Electronics, Cambridge University, Press, (1991).
4. A.N. Matveev, Optics, Mir Publisher, (1988).
5. M.S. Sodha, A.K. Ghatak& V.K. Tripathi, Self-Focusing of Laser beams, Tata McGraw Hill, (1974).
6. J. Wilson and J.F.B. Hawkes, Optoelectronics, Prentice Hall, (1989).

M.Sc. (Physics) NEP Semester-III
Paper Code: MSU0325MEL916I5
Paper title: Solar photovoltaic and thermal systems
Total Credits: 4-credits

(Energy Studies-3)
Solar Photovoltaic and Thermal Systems

Unit I: Solar Photovoltaic energy **(15)**
Interaction of solar radiations with semiconductors, photovoltaic effect, types of solar cell, ideal properties of semiconductor for use its solar cell, carrier generation and recombination, dark and illuminated characteristics of solar cell, solar cell output parameters: RL, Voc, Isc, Pm, FF, efficiency, performance dependence of a solar cell on band gap energy, diffusion length and carrier life time, effect of irradiation and temperature. Classification of PV systems and components, Distributed PV System, Stand-alone PV system, grid Interactive PV System, small system for consumer applications, hybrid solar PV system, concentrator solar photovoltaic. System components - PV arrays, inverters, batteries, charge controls, net power meters, PV system applications.

Unit II: Solar cell Technology **(15)**
Types of Solar cells: Mono -crystalline, crystalline, poly–crystalline cells, Thin film solar cell, Advantage of thin film, Cadmium Telluride Solar Cell, CIGS solar Cell, CZTS solar cell, New materials for thin film solar cell, DSSC, Solution processed thin film, Organic Solar Cell, Hydride Perovskite solar cell and multijunction tandem solar cells., Si solar cells: Fabrication methods.

Unit-III: Solar Thermal Systems **(15)**
Flat plate collectors: Selective surfaces its characteristics and examples, energy balance equation for flat plate collector, thermal analysis of a flat plate collector, efficiency of flat plate collector, solar cookers, solar thermal systems for various applications, solar dryers and industrial products, problems.

Unit IV: Concentrating solar energy collectors **(15)**
Reasons for using concentrating collectors, thermodynamic limits to concentration, optical limits to concentration, various types of concentrators, compound parabolic concentrators (CPC) and its thermal analysis, tracking of the sun, continuously tracking solar concentrators. Concentrated Solar thermal Power generation. Review of Power plants.

Reference Books:

1) Duffle and Beckman, Solar Thermal Engineering Process, John Wiley & Sons, New York
2) A.B. Meinel and M.B. Meinel, Applied Solar Energy, Addison – Wiley Pub. Co., Reading
3) P.J. Lunde, Solar Thermal Engineering, John Wiley & Sons, New York
4) H.P. Garg, Advanced in Solar Energy Technology, D. Reidel Publishing Co., Drdricht.
5) S.P. Sukhatme, Solar Energy, Tata McGrew Hill Company Ltd., New Delhi
6) M.A. Greaen "Solar Cells – Operating Principles, Technology, and System Applications", 1983 Prentice Hall, Inc. New Jersey.
7) F. Kreith and J.F. Kreider, Principles of Solar Engineering Hemisphere Publishing Coro.
8) Chetan Singh Solanki., Solar Photovoltaic: "Fundamentals, Technologies and application", PHI Learning Pvt., Ltd., 2009.

9) Jha A.R., “Solar Cell Technology and Applications,” CRC Press, 2010.
10) John R. Balfour, Michael L. Shaw, Sharlave Jarosek., “Introduction to Photovoltaics”, Jones & Bartlett Publishers, Burlington, 2011.
10) Luque A. L. and Andreev V.M., “Concentrator Photovoltaic”,Springer, 2007.
11) Partain L.D., Fraas L.M., “Solar Cells and Their Applications,” 2nd ed., Wiley, 2010.
12) Solar energy conversion: The solar cell, by Richard C. Neville.
13) Photo electrochemical solar cells – Suresh Chandra
14) Solar energy conversion – A. E. Dixon and J. D. Leslie.
15) Solar cells – Martin A. Green
16) Direct energy conversion (4th edition) – Stanley W Angrist.
17) Principles of solar engineering by Frank Kreith and JanfKreider.
18) Solar Energy Engineering, A. A. M. Sayigh
19) Selective surfaces by O.P. Agnihotri

M.Sc. (Physics) NEP Semester-III
Paper Code: MSU0325MEL916I6
Paper title: Special Materials
Total Credits: 4-credits

(Material Science – 3)
Special Materials

Unit I Composite materials (15)

Introduction, Reinforcing materials for fibrous composites, Manufacture of fiber composites, Elastic properties of a composite, Strength of a fiber composite, Specific stiffness and specific strength, Toughness of fibre composites, Fracture toughness of polyblends.

Unit II Glasses (15)

Glasses: Types of glasses, role of oxides in glasses, glass transition temperature, optical properties of glasses, electrical properties of glasses, electronically conducting glasses, special glasses, metallic glasses.

Unit III Functional Materials (15)

Nanophase materials: Introduction, synthesis and techniques, Nucleation and growth mechanism, properties of Nanophase Materials, Applications.

Advanced Ceramics: Introduction, Classification of Ceramics, Structure of the Ceramics, Ceramic Processing, Properties of Ceramics, Applications.

Polymer Materials: Introduction, Polymerization Mechanism, Degree of Polymerization, Classification of Polymers, Structures of polymer and preparation methods, important properties and applications of polymers. (Nylon, Polyesters, Silicones, Composites, Composite material including nanomaterial)

Unit IV Ferroelectrics, Piezoelectrics and Pyroelectrics (15)

Ferroelectrics: Ferroelectric phenomena, Types of ferroelectrics, Theory of ferroelectric displacive transitions, Ferroelectric and antiferroelectric transition, Formation and dynamics of ferroelectric domains, Experimental evidence of domain structure, ferroelectric materials, and their applications.

Piezoelectric: Piezoelectric phenomena, Phenomenological approach to piezoelectric effects, Piezoelectric parameters and their measurements, Piezoelectric materials, and their applications.

Pyroelectrics: Pyroelectric phenomena, Phenomenological approach to pyroelectric effects, Pyroelectric parameters and their measurements, pyroelectric materials, and their applications.

Reference Books:

1)Modern composite materials - L. J. Broutman and R H Krock Addition-Wesley Pub. Co., Massachusetts (1967)
2) Glass science - R H Doremus, John Wiley and sons, N. Y. (1973)
3) Physical properties of glass - D. G. Holloway Wykeham publications, London (1973)
4) Introduction to ceramics - W. D. Kingery, John Wiley and sons, N. Y. (1960)
5) Charles Kittle; Introduction to Solid State Physics, 7th Edition, John Wiley & Sons
6) M.A.Wahab; Solid State Physics: Structure and Properties of Materials, Alpha Science International (2005)
7) Materials Science: V. Rajendran, A. Marikani, Tata MC Graw Hill
8) Materials Science & Engineering: Raghavan, Tata MC Graw Hill

9) Materials Science: Arumugam
10) Materials Science &Metallurgy: O. P. Khanna
11) Materials Science and Engineering: Callister S.

M. Sc. - II
(Semester – IV)

M.Sc. (Physics) NEP Semester-IV
Course Code: MSU0325MML916J1
Paper title: Electrodynamics
Total Credits: 4 - credits

Electrodynamics

Unit - I: Maxwell's Equations and E.M. Waves: (15)

Maxwell's Equations: microscopic and macroscopic forms (revision), Maxwell's equations in free space, dielectrics and conductors, conservation of the bound charge and current densities (Equation of Continuity and Displacement Current), E.M. wave equations in waveguide of the arbitrary cross section: TE and TM modes; Transmission lines and wave guides, rectangular and circular waveguides , dielectric waveguide, resonant cavity. Reflection and refraction, polarization, Fresnel's law, interference, coherence, and diffraction.

Unit - II: Time –Dependent Potentials and Fields: (15)

Scalar and vector potentials: coupled differential equations, Gauge transformations: Lorentz and Coulomb Gauges, Retarded Potentials, Lienard – Wiechert Potentials, Fields due to a charge in the arbitrary motion.

Unit - III: Radiation from Accelerated Charges and Radiation Reaction: (15)

Fields of charge in uniform motion, applications to linear and circular motions: cyclotron and Synchrotron radiations, Power radiated by point charge – Larmor's formula, Angular distribution of radiated power, Cerenkov radiation and Bremsstrahlung (qualitative treatments). Radiation Reaction: criteria for validity, Abraham –Lorentz formula, Physical basis of radiation reaction –self force.

Unit - IV: Electrodynamics and Relativity: (15)

Geometry of Relativity, the Lorentz Transformations, The Structure of Space time, Relativistic Mechanics, Proper Time and Proper Velocity, Relativistic Energy and Momentum, Relativistic Kinematics, Relativistic Dynamics, Relativistic Electrodynamics Field Tensor, Relativistic Potential. Four vectors and Tensors: covariance of the equation of Physics, Transformation of Electric field, Lorentz transformation as orthogonal Transformation in Fourier dimensions, Proper time and light cone, Relativistic Particle- Kinematics and dynamics, Covariant Lorentz force.

Reference books:

1) Introduction to Electrodynamics – D. J. Griffiths (Prentices- Hall 2002 (3rd edn)
2) Foundation of E.M. Theory- J. R. Reitz, F.J. Milford & R.W. Christy (Narosa Publication House 3rd edition 1993)
3) Classical Electrodynamics – J. D. Jackson (Wiley Eastern 2nd edition)
4) Classical Electrodynamics –S. P. Puri (Tata McGraw Hill 1990)
5) Electromagnetics - Laud B. B. - New Age International Private Limited; 3rd edition

M.Sc. (Physics) NEP Semester-IV
Course Code: MSU0325MML916J2
Paper title: Nuclear and Particle Physics
Total Credits: 4 - credits

Nuclear and Particle Physics

Unit-I Nucleon-Nucleon Interaction: **(15)**

Nature of the nuclear forces, form of nucleon-nucleon potential, Deuteron problem: The theory of ground state of deuteron, excited states of deuteron, n-p scattering at low energies (cross-section, phase shift analysis, scattering length, n-p scattering for square well potential, effective range theory); p-p scattering at low energies (cross-section, experiment and results) ; exchange forces, tensor forces; high energy N-N scattering (qualitative discussion only of n-p and p-p scatterings), charge-independence and charge-symmetry of nuclear forces.

Unit-II Nuclear Models: **(15)**

Evidences for shell structure, single-particle shell model, its validity and limitations, collective model: collective vibration and collective rotation, single particle motion in a deformed potential

Unit-III Nuclear Reactions: **(15)**

Elementary ideas of alpha, beta and gamma decays and their classifications, characteristics, selection rules and basic theoretical understanding. Nuclear reactions, reaction mechanism, Compound nucleus reaction (origin of the compound nucleus hypothesis, discrete resonances, continuum states), optical model of particle-induced nuclear reaction and direct reactions (experimental characteristics, direct inelastic scattering, and transfer reactions). Fission and fusion, Fission, and heavy ion reactions.

Unit-IV Particle Physics: (15)

Classification of fundamental forces. Classification of Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.). Gellman-Nishijima formula. Quark model, CPT invariance. Application of symmetry arguments to particle reactions, Parity non-conservation in weak interaction, Relativistic kinematics.

Reference Books:

1. Nuclear and Particle Physics- W.E. Burcham and M.Jobes, (Addison Wesley, Longman, England, 1995).
2. Introduction to Particle Physics- M.P. Khanna (Prentice Hall, India, 1999).
3. Concept of Nuclear Physics, B.L. Cohen, (Tata McGraw-Hill, 2005)
4. Nuclear Physics Principles and Applications, John Lilley, (John Wiley and Sons (Asia) 2001)
5. Nuclear physics – D. C. Tayal. (Himalaya Publishing House,1997)
6. Nuclear Physics- Iriving Kaplan (Narosa, Madras, 1989).
7. Introduction to High Energy Physics- Donald H.Perkins (Addison Wesley, Massachusetts, 1982).

M.Sc. (Physics) NEP Semester-IV
Course Code: MSU0325MMP916J1 (SSP- VII)
Paper title: SOLID STATE PHYSICS LAB –V & VI
Total Credits: 4-credits

Laboratory/ Practical Course-SSP-VII
(Solid State Physics Lab –VII)

List of Experiments:
Group I:
[1] Particle size analysis by dynamic light scattering

[2] Photo electrochemical Solar Cell

[3] Characteristics of phototransistor and LDR

[4] Spectral response of solar cell

[5] Gas sensing properties of thin film

[6] I-V characteristics of solar panel

[7] Analysis of EIS spectrum

[8] I-V characteristics and solar cell parameters

Group II:
[9] Analysis of FT-IR and FT-IR spectra

[10] Cyclic Voltammetry and electro-chromism

[11] Super capacitive behaviour of MnO_2 sample

[12] Specific area by BET method

[13] Analysis of PL spectrum and calculation of life time of defects

[14] Analysis of TG-DTA pattern

[15] Analysis of XAFs pattern

Solid State Physics Project Work - II (6 credits)

M.Sc. (Physics) NEP Semester-IV
Course Code: MSU0325MMP916J1 ((SP- VII)
Paper title: SPACE PHYSICS LAB –VII
Total Credits: 4-credits

Laboratory/ Practical Course-SP-VII
(Space Physics Lab –VII)

List of Experiments:
1. Sky observations-I (Moon & Planets)
2. Sky observations-II (Binary stars & Nebula)
3. Geomagnetic Indices-Kp and Ap
4. Interplanetary Magnetic Field (IMF)
5. Sun's Magnetogram
6. Solar Dynamic Observatory (Sun Now)
7. Solar Proton Events
8. Geomagnetic Events
9. Magnetometer
10. GOES Electron Flux
11. GOES Magnetometer
12. GOES Proton Flux
13. GOES Solar X-ray Imager
14. GOES X-ray Flux
15. LASCO Coronagraph
16. Planetary K-index
17. Real Time Solar Wind
18. Van Allen Probes Radiation Belt

Space Physics Project Work - II (6 credits)

M.Sc. (Physics) NEP Semester-IV
Course Code: MSU0325MMP916J1 ((TH- VII)
Paper title: THEORETICAL PHYSICS LAB –VII
Total Credits: 4-credits

Laboratory/ Practical Course-TH-VII
(Theoretical Physics Lab –VII)

THEORETICAL PHYSICS LAB–VII (4-credits)
ADVANCED MATHEMATICA TUTORIALS:
2. Introduction to Mathematica for Scientists and Engineers (Notebook form in Mathematica Tutorials)
IMSE Ch7: Complex
IMSE Ch8: Fourier
IMSE Ch9: Programming
IMSE Ch10: Statistics
IMSE Ch5: Input-Output
IMSE Ch6: Solve – Numerical Solutions

List of Experiments:
From Schaum's Outlines: Mathematica (Eugene Don)
Chapter 7: Algebra and Trigonometry
Chapter 7: Differential Calculus
Chapter 9: Integral Calculus
Chapter 10: Multivariate Calculus
Chapter 11: Ordinary Differential Equations
Chapter 12: Linear Algebra
3. Assignments

Theoretical Physics Project Work - II (6 credits)

M.Sc. (Physics) NEP Semester-IV)
Course Code: MSU0325MMP916J1 ((MO- VII)
Paper title: MODERN OPTICS LAB –VII
Total Credits: 4-credits

Laboratory/ Practical Course-SP-VII
(Modern Optics Lab –VII)

List of Experiments:

1) Fabry-Parot etalon – Exact fraction method
2) CD-spectrometer by using Hydrogen and Helium lamp.
3) Solar Spectrum
4) Temperature of flame
5) Vibrational analysis of AlO
6) Vibrational analysis of C2
7) Alloy analysis
8) Verification of Beer- Lambert law- Absorption spectra of KMnO4 solution
9) Recording and Analysis of FT-IR spectra
10) Recording and Analysis of UV-Vis spectra
11) Recording and Analysis of PL spectra
12) Hologram recording of vibrating surfaces (Holographic Interferometry)
13) Determination of mechanical / thermal stress by holographic interferometry

*Depending on availability of new experimental kits, few new experiments will be added to this list.

Tutorial: There will be a tutorial in practical examination based on these experiments.

Modern Optics Project Work - II (6 credits)

M.Sc. (Physics) NEP Semester-IV
Course Code: MSU0325MMP916J1 ((MO- VII)
Paper title: ENERGY STUDIES LAB –VII
Total Credits: 4-credits

Laboratory/ Practical Course-SP-VII
(Energy Studies Lab –VII)

List of Experiments:

1. Solar Line Concentrator (I)
2. Solar Line Concentrator (II)
3. Solar Pont Concentrator
4. Solar Still
5. Solar Dryer
6. Solar Cooker
7. Flat Plate Collector
8. PV – IV Characteristics
9. PV-Water Pumping System
10. PV-Spray System
11. Flue Gas Analyzer
12. Wind Energy Conversion
13. Particle Size Measurement
14. Close Cycle Cryogenic System
15. Hot Water Bumb
16. 3kW Aerogenerator

Energy Studies Project Work - II (6 credits)

M.Sc. (Physics) NEP Semester-IV
Course Code: MSU0325MMP916J1 ((MS- VII)
Paper title: MATERIAL SCIENCE LAB –VII
Total Credits: 4-credits

Laboratory/ Practical Course-MS-VII
(Material Science Lab –VII)

List of Experiments:

1. Solar Line Concentrator (I)
2. Solar Line Concentrator (II)
3. Solar Pont Concentrator
4. Solar Still
5. Solar Dryer
6. Solar Cooker
7. Flat Plate Collector
8. PV – IV Characteristics
9. PV-Water Pumping System
10. PV-Spray System
11. Flue Gas Analyzer
12. Wind Energy Conversion
13. Particle Size Measurement
14. Close Cycle Cryogenic System
15. Hot Water Bumb
16. 3kW Aerogenerator

Material Science Project Work - II (6 credits)

Semester-IV
Elective Paper
Choose any on elective paper from specialization)

Sr. No.	Course Code	Paper Title
1	SSP-4	Physical Properties of solids (4-credits)
2	SP-4	Astrophysics of the Sun (4 credits)
3	TH-4	Introduction to Quantum Field Theory (4-credits)
4	MO-4	Holography and Its applications (4-credits)
5	ES-4	Energy Storage and Energy Audit (4 credits)
6	MS-4	Nanostructured Materials (4 credits)

M.Sc. (Physics) NEP Semester-IV
Paper Code: MSU0325MEL916J1
Paper title: Physical properties of solid
Total Credits: 4-credits

(Solid State Physics - 4)
Physical properties of Solids

Unit 1: Electronic Structure of Crystals (15)

Basic assumptions of Model, Collision or relaxation times, DC electrical conductivity, Failures of the free electron model, The tight-binding method, Linear combinations of atomic orbitals, Application to bands from s-Levels, General features of Tight-binding levels, Wannier functions, Other methods for calculating band structure, Independent electron approximation, general features of valence band wave functions, Cellular method, Muffin Tin potentials, Augmented plane wave (APW) method, Green's function (KKR) method, Orthogonalized Plane Wave (OPW) method Pseudo potentials.

Unit 2: Transport Properties of Metals (15)

Drift velocity and relaxation time, The Boltzmann transport relation, The Sommerfeld theory of metals of electrical conductivity, The mean free path in metals, Thermal scattering, The electrical conductivity at low temperature, The thermal conductivity of metals, Dielectric Properties of insulators, Macroscopic electrostatic Maxwell equations, Theory of Local Field, Theory of polarizability, Clausius- Mossotti relation, Long- wavelength optical modes in Ionic crystals.

Unit 3: Phonons, Plasmons, Polaritons, and Polarons (15)

Vibrations of monatomic lattices: first Brillion zone, group velocity, Long wavelength limit, Lattice with two atoms per primitive cell. Quantization of lattice vibrations, Phonon momentum Dielectric function of the electron gas, Plasma optics, Dispersion relation for Electromagnetic waves, Transverse optical modes in a plasma, Longitudinal Plasma oscillations, Plasmons, Polaritons, LST relations, Electron- electron interaction, Electron phonon interaction: Polarons.

Unit 4: Defects in crystals (15)

Thermodynamics of point defects, Schottky and Frenkel defects, annealing, electrical conductivity of ionic crystals, color centers, Polarons and exciton, dislocations, strength of crystals, crystal growth, stacking faults and grain boundaries.

Reference Books:

1. Solid State Physics by N W Ashcroft and N D Mermin, HRW, International editions (1996) (Units 1, 2 and 3)
2. Introduction to Solid State Physics by C Kittle (4th edition) John Willey Publication (1979) (Units 3)
3. Solid State Physics by A J Dekker ((1986) Macmillan India Ltd

M.Sc. (Physics) NEP Semester-IV

Paper Code: MSU0325MEL916J2
Paper title: Astrophysics of the Sun
Total Credits: 4-credits

(Space Physics-4)
Astrophysics of the Sun

Unit-I: The Sun (15)
Characteristics of the Sun, internal structure, solar observations, solar atmosphere, oscillations, Convection, rotation, magnetism, chromo sphere, corona, solar wind, quiet, Sun, Active Sun, Helioseismology.

Unit-II: The Sun and its Emissions (15)
Solar electromagnetic radiations-radio, far IR, IR-Visible, UV, extreme UV, X-ray (soft and hard), solar cycle and solar variability, magnetic field energy-solar flares and coronal mass ejections

Unit-III: The Sun and its Magneto hydrodynamics (15)
Introduction, the sun, role of solar magnetic field, MHD equilibria, waves and instabilities, solar activities, prominences, coronal heating, solar flares, coronal mass ejections.

Unit-IV: The Solar wind and its interactions with magnetized planets (15)
solar energetic particles-solar wind, Properties of solar wind, origin of solar wind, magnetic structure of the corona and solar wind, major time dependent disturbances of solar wind, planetary magnetic fields, Size of magnetic cavity, shape of magnetic cavity, self-consistent models, flow around the magnetosphere.

Reference Books:
1. Foundations of Astronomy by Michael a. Seeds
2. The Sun – An Introduction by Michael Stix, Second Edition, A & A Library, Springer
3. High Energy Astrophysics, MALCOLM S. LONGAIR, Third Edition, Cambridge university press, 2011, ISBN 978-0-521-75618-1
4. Introduction to Space Physics by Margaret G. Kivelson (Editor), Christopher T. Russell (Editor)
5. Magnetohydrodynamics of the Sun, By Eric Priest, Cambridge University Press, June 2014
6. Advanced Magnetohydrodynamics: With Applications to Laboratory and Astrophysical Plasmas by J. P. Goedbloed, Rony Keppens, Stefaan Poedts.
7. Elements of space physics by R. P. Singhal, PHI learning Private limited, Delhi
8. Fundamentals of Solar Astronomy by Arvind Bhatnagar and William Livingston, World Scientific (2005)

M.Sc. (Physics) NEP Semester-IV
Course Code: MSU0325MEL916J3
Paper title: Introduction to Quantum Field Theory
Total Credits: 4-credits

(Theoretical Physics-4)
Introduction to Quantum Field Theory

Unit-I: Single particle relativistic wave equation (15)
Relativistic Notation, Klein-Gordan equation, Dirac equation, Prediction of antiparticles, Dirac matrices and Dirac spinors, Non-relativistic limit and electron magnetic moment, Relevance of Poincare group: spin operators and zero mass limit, Maxwell and Proca equations.

Unit-II: Canonical quantization of spin zero, spin half and spin one fields (15)
Lagrangian formulation, The real scalar field, Complex scalar field and electromagnetic field, Canonical quantization of real and complex Klein-Gordan field, Canonical quantization of Dirac field, Quantization of electromagnetic field, The massive vector field.

Unit-III: Path integral quantization of spin zero and spin half fields (15)
Path integral formulation of quantum mechanics, Perturbation theory and S-matrix, Coulomb scattering, Generating functional for scalar fields, Functional integration, Free Green's function, The S-matrix and reduction formula, Scattering cross section.

Unit-IV: Path integral quantization of gauge fields (15)
Propagators and gauge conditions in QED, Non-Abelian gauge fields, Self-energy and vertex function, Ward-Takahashi identities in QED, Gauge Theory of Standard Model, Spontaneous Symmetry breaking and Higgs Mechanism.

Reference Books:

1. Quantum Field Theory, Lewis Ryder, Cambridge Press.
2. Student Friendly Quantum Field Theory, Robert Klauber, Sandtrove Press; 2nd Edition.
3. An Introduction to Quantum Field Theory, Michael Peskin and Daniel Schroeder, Westview Press.
4. Diagrammatica, Martinus Veltman, Cambridge Press.
5. The Quantum Theory of Fields Vol. I and II, Steven Weinberg, Cambridge Press.
6. Quarks and Leptones: An Introductory Course in Modern Particle Physics, Francis Halzen and Alan D. Martin (Wiley)

M.Sc. (Physics) NEP Semester-IV
Course Code: MSU0325MEL916J4
Paper title: Holography and Its applications
Total Credits: 4-credits

(Modern Optics -4)
Holography and Its applications

Unit – I: Introduction to Basic Concepts: (15)

Optical holography, Light waves, hologram formation, wave front reconstruction, Plane and Volume hologram formation geometries, Basic holography equations. Beginning of Optical Holography, in - line (Gabor) hologram, the off-axis hologram, Image hologram, Fraunhofer Hologram, Thin hologram and Volume hologram, Properties of holograms. Critical assessment of Holograms.

Unit – II: Optical system and Hologram recording materials (15)

Optical system: Mechanical Stability in Hologram Formation, Fringe visibility, Optical components, Coherence requirements. Temporal coherence of laser light, Laser safety.
Hologram Recording Materials: Optical changes in Photosensitive materials, Exposure & sensitivity, Recording resolution, Noise and Recording Linearity and Ideal recording material, Silver halide photographic emulsion, Photoconductor-Thermoplastic films, Dichromate gelatin films, Thermoplastic films, Photochromic materials.

Unit – III: Holography and Interferometry (15)

Color Holography, Computer generated holograms in optical testing, Time gated holography, Hologram copying, Acoustical Holography.
Holographic Interferometry: Time average holographic Interferometry, Real time & Double exposure holographic interferometry, electronic holographic interferometry, Difference holographic interferometry.

Unit – IV: Applications of Holography: (15)

Imaging applications: Holographic microscopy; Particle size analysis; multiple imaging,
Holographic optical elements: Diffraction gratings; filters; scanners,
Information storage and processing: Associative storage; pattern recognition; coding and multiplexing; Image processing; information storage.
Holography and communication: Holographic Diffuser Screen, Holographic Display, Holographic TV, Holographic Movie, Holography in solar energy and Architecture

Text and Reference Books:

1. R. J. Collier, C.B. Burukhardt, L. Lan, Optical Holography, Academic Press (1971).
2. P. Hariharan, Optical Holography, Cambridge University Press, (1984)
3. G.K. Ackermann, J. Eichler, Holography- a practical approach, Wiley-VCH, (2007).
3. H.M. Smith, Principles of Holography, Wiley Interscience Inc., (1969).
4. L. M. Soroko, Holography & Coherent optics, Plenum Press, (1980).

M.Sc. (Physics) NEP Semester-IV
Course Code: MSU0325MEL916J5
Paper title: Energy Storage and Energy Audit
Total Credits: 4-credits

(Energy Studies-4)
Energy Storage and Energy Audit

Unit-I: Introduction to energy storage (15)

Introduction to energy storage, energy density, power density, need for energy storage and different modes of energy storage. Electrochemical Energy storage principle and component.

Supercapacitors: Principle of working and construction, Types of supercapacitors, Materials for Supercapacitors.

Unit-II Energy storage systems (15)

Design and Construction of batteries, Primary batteries: Leclanche, Duracell and Lithium primary batteries, Lead Acid Batteries, Nickel-Metal Hydride batteries, silver peroxide zinc battery,

Secondary batteries: Lithium-Ion Batteries and Lithium polymer batteries, Sodium batteries, Thin-film Batteries, Redox flow batteries, Metal Air Batteries, Energy Storage for Fuel Cells; Hydrogen storage-Hydrogen Economy, Different modes of hydrogen storage, compressed gas storage, liquid hydrogen storage, metal hydrides, Types of fuel cells.

Unit III: Energy Audit (15)

Need for energy audit, Difference between energy audit and energy management. Basic concepts in energy audit, Methodology for energy audit, Types of Energy Audit: Walk through Audit, Detailed Audit, Investment grade; Planning for Energy Audits; Conducting the Audit: Pre-Audit Activities, Pre-Audit Visit, Actual data collection, Analysis, Draft Report, Discussion with Client; Final Report; Further Analysis; Report Submission; Role of Codes and Standards: Government Standards, Industry Association Standards, International Standards, Industry norms

Case studies: Energy audit in buildings, Energy audit in industrial plant.

Unit-IV: Instruments used for Energy Audit Measurements (15)

Ultrasonic water flow meters, Anemometers, Pressure Gauges, Manometers, Thermometers: All types, Power Quality Analyzers and loggers, Infrared Thermometers, Lux meter, Pitot Tubes, Flue gas Analyser: Chemical and Electronic types, Tachometers: Contact and non-contact type, Humidity measurement devices

Reference Books

1) Energy Storage: Fundamentals, Materials and Applications by Robert A. Huggins; Springer, 2010.
2) Handbook of battries and fuel cells – Lindsey. David
3) Energy Storage Systems, by S. Kakac, BirolKilkis, 1989
4) A. R. Pendse, "Energy Storage Science and Technology", SBS Publishers & Distributors Pvt. Ltd., New Delhi, (ISBN - 13:9789380090122), 2011.
5) Thomas Reddy, Linden's Handbook of Batteries, 4th Edition, McGraw-Hill Education.
6) Energy Management, Audit and Conservation" by Barun Kumar De
7) Guide to Energy Management" by Barney L
8) Fundamentals of Energy Conservation and Audit" by Agarkar Santosh Vyankatro and MatetiNaresh Kumar
9) Industrial Energy Conservation (UNESCO Energy Engineering)" by Charles M Gottschalk

M.Sc. (Physics) NEP Semester-IV
Course Code: MSU0325MEL916J6
Paper title: Nanostructured Materials
Total Credits: 4-credits

(Materials Science – 4)
Nanostructured Materials

Unit I: Nano-Material Synthesis and Characterization (15)
Material Synthesis: Physical Methods: Introduction, methods based on evaporation, sputter deposition, chemical vapour deposition, electro deposition, ion beam technique, Chemical Methods: Introduction, colloids and colloidal solutions, growth of nanoparticles, sol-gel method.

Unit II: Characterizations and Applications of Nanostructured Materials (15)
Material Characterization: Analysis by XRD, XPS, SEM/FESEM, FT-IR, UV-Vis, Raman Spectroscopy, AFM, TEM, TG-DTA, Wettability and contact angle measurement. Electronics, energy, automobiles, sports and toys, textile, cosmetic, domestic appliances, space, and defense, medical, nanotechnology and environment.

Unit III: Nano-Biomaterials (15)
Biomaterial requirements, Dental materials, bore materials, Reconstructive surgery materials, Drug delivery system, Carbon Nanomaterials as Nanocarriers for Drug Delivery: Concepts and Challenges, Delivery of Anticancer Drugs

Unit IV: Environmental and Social issues of Nano-Materials Science **(15)**
Recycling issue of materials science, World banned materials, Salty of hazards materials, Nanomaterials and health, Nanomaterials and the environment, Sustainable nonmanufacturing and green nanotechnology, Societal and ethical considerations.

Reference Books

1) Physical metallurgy principles - R. E. Reed-Hill, Affiliated East-west press Pvt. Ltd., New Delhi (1973)
2) Physical Metallurgy andAdvanced Materials, Seventh edition,R. E. Smallman and A. H.W. Ngan. Published by Elsevier Ltd. (2007)
3) Structure and principle of engineering materials - R. M. Brick, A. W. Pense and R. B. Gordon, McGraw-Hill Kogakusha, Ltd., Tokyo (1977)
4) Introduction to materials science for engineers - J.F. Shackelford McMillan, N. Y. (1985)
5) Modern composite materials - L. J. Broutman and R H Krock Addition-Wesley Pub. Co., Massachusetts (1967)
6) Materials science, testing, and properties for technicians - W. O. Fellers Prentice Hall, N. J. (1990)
7) Elements of materials science -L. H. van Vlack Addition-Wesley, Massachusetts (1959)
8) Introduction to ceramics - W. D. Kingery, John Wiley and sons, N. Y. (1960)
9) Carbon Nanomaterials for Biomedical Applications, Mei Zhang, Rajesh R. Naik, Liming Dai. Springer International Publishing Switzerland 2016
10) Nanotechnology Environmental Health and Safety, Second Edition, Matthew S. Hull and Diana M. Bowman. Published by Elsevier Inc. (2014)

9. Scheme of Teaching

M. Sc. Programme Structure for Semester I and II

Semester I											
Teaching Scheme					Examination Scheme						
Sr. No.	Theory (TH)				**Practical (PR)**	Semester-end Examination (SEE)			Internal Assessment (IA)		
	Course Type	No. of Lectures per Week	Hours	Credits		Paper Hours	Max	Min	Internal	Max	Min
1	MM1	4	4	4		3	80	32	--	20	08
2	MM2	4	4	4		3	80	32	--	20	08
3	ME1	4	4	4		3	80	32	--	20	08
4	RM	4	4	4		3	80	32	--	20	08
5	Practical Lab- I	4	8	4		6	100	40	--	--	--
6	Practical Lab- II	2	4	2		3	50	20	--	--	--
Total		22	28	22			470			80	
							Total (SEE +IE) = 470 + 80 = 550				

Semester II											
Teaching Scheme					Examination Scheme						
Sr. No.	Theory (TH)				Practical (PR)	Semester-end Examination (SEE)			Internal Assessment (IA)		
	Course Type	No. of Lectures per Week	Hours	Credits		Paper Hours	Max	Min	Internal	Max	Min
1	MM3	4	4	4		3	80	32	--	20	08
2	MM4	4	4	4		3	80	32	--	20	08
3	ME2	4	4	4		3	80	32	--	20	08
4	OJT/FP	4	4	4		3	80	32	--	20	08
5	Practical Lab- III	4	8	4		6	100	40	--	--	--
6	Practical Lab- IV	2	4	2		3	50	20	--	--	--
Total		22	28	22			470			80	
							Total (SEE +IE) = 470 + 80 = 550				
Semester I and II		44	56	44			**Total = 550 + 550 =1100**				

MM: Major Mandatory – There will be TWO mandatory courses for each semester.
ME: Major Elective (Student should opt for ANY ONE course from the group of elective course/basket).
RM: Research Methodology – It is mandatory course
OJT/FP: On Job Training- Internship/Apprenticeship or Field Project: It is mandatory course. **It**

should be completed during the period from the end of first semester to the end of second semester.

NOTE: Separate passing is mandatory for both, semester End Examination and internal

Evaluation/Assessment.

10. Examination Pattern

Provide the examination pattern separately for each of the following

Theory:

Practical:

On Job Training:

Field Project:

Research Methodology:

11. Nature of Question Paper and Scheme of Marking

Theory:

Theory: Time -3 hours, **Marks**-80

Instructions: **1) Question No.1 is compulsory.**
2) Attempt any four questions from Q.2 to Q.7

Question 1: Answer in Short (8 short questions – each having -2 Marks) - 16 marks

Question 2: a) Long Answer question for - 12 marks
b) Short answer questions for - 4 marks

Question 3: a) Long Answer question for - 12 marks
b) Short answer questions for - 4 marks

Question 4: a) Long Answer question for - 12 marks
b) Short answer questions for - 4 marks

Question 5: a) Long Answer question for - 12 marks
b) Short answer questions for - 4 marks

Question 6: a) Long Answer question for - 12 marks
b) Short answer questions for - 4 marks

Question 7: a) Long Answer question for - 12 marks
b) Short answer questions for - 4 marks

Note: Equal weightage should be given to each unit.

Practical:

12. Equivalence of courses

M. Sc. Part I (Semester I and II)

Old Course				Equivalent Course		
Sem No.	**Course Code**	**Title of Old Course**	**Credit**	**Course Code**	**Title of New Course**	**Credit**
I						
I						
I						
I						
I						
I						
II						
II						
II						
II						
II						
II						