SCHOOL OF SCIENCES
(FORMERLY, SCHOOL OF ARCHITECTURE, SCIENCE AND TECHNOLOGY)
YASHWANTRAO CHAVAN MAHARASHTRA OPEN UNIVERSITY

Syllabus:

V153: M.Sc. (Physics){2023 Pattern}

(Semester 01 to 04)

(Incorporating NEP2020 Recommendations, PG Credit and Curriculum Framework GR dated 16-05-2023)

With effect from Academic Year 2023-24, vide G.R. No. NEP-2022/CR No. 09/VISHI-3/शिकाना, dated 16 May, 2023.

2023

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NEP2020: Programme Structure with Syllabus of all Courses at Semester 01 to 04 was finalized in PAC meeting held on 24 July 2023.

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Revised on 2 Sept 2023, 25 Nov 2023 for Evaluation Pattern

V153:M.Sc.(PHYSICS){2023 PATTERN}

Physics is the normal science that ponders the matter, its movement and behavior through space and time, and the related substances of vitality and drive. Physics is one of the foremost essential logical disciplines and its fundamental objective is to get it the behavior of universe and its characteristics.

Physics uses the logical method to assist reveal the fundamental standards overseeing light and matter, and to find the suggestions of those laws. It accept that there are rules by which the universe capacities, which those laws can be at slightest mostly caught on by people. It is additionally commonly accepted that those laws may be utilized to anticipate everything almost the universe's future on the off chance that total data was accessible almost the show state of all light and matter.

On consideration of Space science, the Material science got to be one of the most seasoned scholarly disciplines. Physics converges with numerous intrigue ranges of inquire about. Modern thoughts in Material science frequently clarify the basic components examined by other branches of science and recommend unused roads of investigate in scholarly disciplines such science etc. Progression in Physics regularly leads to modern innovations.

About the Programme

PROGRAMME CODE: V153

PROGRAMME NAME: M.SC (PHYSICS)

This M.Sc.programme is uniquely designed to impart essential knowledge in all major areas of pure or applied Physics. This programme offers an exciting opportunity for specialization in Physics to model and solves different real-life problems. The course contents of total 04 semesters are a carefully selected blend of theory and practical which prepares students for specialist professional employment, research in academia, and various industries for broader applications. Learner centric curriculum is designed in adherence to the principles of National Education Policy (NEP 2020) to acquire knowledge and skills with valuable experiences through hands-on activities, projects and internships.

Programme Objective and Scope

This programme is designed to achieve following objectives and scope.

Objectives: After successful completion of this programme, students will be able to

1. Identify, formulate and solve Physics problems
2. Design and conduct experiments as well as analyse and interpret data
3. Apply knowledge of Physics in a different stream of science and to communicate effectively.
4. Aquire ability to use the techniques, skills, and modern physical tools in real world application.
5. Engage in life-long learning and will have recognition.

Scope of the Physics programmes: After successful completion of this programme, students may get opportunities in various fields/sectors to work as

- Career opportunities in both private and government sector/ in India and abroad
- Job opportunities in allied sectors [High Tech Industries, Medical Labs, Government Hospitals, Medical Research Labs, Defense Services, Nuclear Power Plants, Aerospace Sector, Research Analyst, Space and Astronomy, Healthcare, Technology, Geo-Physics and meteorology, College Lecturer/ Professor Banking, Business/ Start-up
- Inculcation of research attitude
- Inculcation of entrepreneurship
- Perceive higher education and research in the same field

Programme Outcomes

The Master of Science programme in Physics imparts students with:

- Knowledge to comprehend and appreciate a great variety of phenomena occurring in the Universe, both at micro and macroscopic level in non- relativistic as well as relativistic realm through understanding of basic concepts of Physics.
- Exposure to research within one of the research areas represented at the Department of Physics, through supervised Master Dissertation project.
- Adequate analytical skills on the advanced levels of Physics, needed for plethora of job opportunities in education, research, and industry.
- Competence in core areas of Physics, which is in line with the international standards, aimed at realizing the goals towards skilled India.

Mode of Education

This Programme will be offered in Open and Distance Learning (ODL) Mode as defined in "UGC Open and Distance Learning Programmes and Online Programmes Regulations, 2020" published in the gazette notification by dated 4th Sept 2020 by the UGC as specified below.

> *"Open and Distance Learning Mode means a mode of providing flexible learningopportunities by overcoming separation of teacher and learner using a variety of media, including print, electronic, online and occasional interactive face-to-face meetings with the learners or Learner Support Services to deliver teaching-learning experiences, including practical or work experiences"*

Mode of Examination

Continuous Assessment is conducted at recognized learner support centres and End Examination for all type of courses is conducted at recognized Exam Centres of the University under supervision.

Basic Information

1. **Mode of Education**: Open and Distance Learning (ODL) Mode
2. **Minimum Programme Duration**: 2 years/ 4 semesters after B.Sc. (PCM)/ B.Sc.(Physics)/B.Sc.(Electronics)/B.E./B. Tech.Degree or Equivalent pass
3. **Maximum Programme Duration:** 4 years from the date of admission to the PG programme, also referred as Valid Registration Period
4. **Learner Support Centers(LSC):**University approved/ recognized Senior Science Colleges/ Institutes offering PG Physics programme
5. **Medium of Instruction**: English
6. **Attendance**: Minimum 80% attendance for all type of courses.
7. **Profile of Prospective Students**: In-Service Science Teachers from Schools/ Junior College and Equivalent pass students
8. **Teaching-Learning**: 15 working weeks per semester
9. **Total Teaching-Learning Support:**Total 2640 Hours including Self-Study during all 4 semesters. 660 Hours (including Self-Study) during each semester.
10. **Total Courses:** Total 23 courses (subjects) distributed over Semesters 01 – 04.
11. **Total Credits:** 88 Credits [As per UGC norms 1 Credit means 30 hours of study efforts required to gain learning of particular content of each credit].
12. **Total Courses and Credit Distribution Scheme:**

Sem	Mandatory Courses (DSC)			Elective Courses (DSE) (4 Credits)	Other Courses (4 Credits)/ (6 Credits)	Total Courses (Credits)
	Theory		Practical (4 Credits)			
	(4 Credits)	(2 Credits)				
1	2	1	1	1	1 – Research Methodology (4 Credits)	**6** (22 Credits)
2	2	1	1	1	Any one - OJT/ Field Projects (4 Credits)	**6** (22 Credits)
3	2	1	1	1	1- Research Project (4 Credits)	**6** (22 Credits)
4	2	-	1	1	1- Research Project (6 Credits)	**5** (22 Credits)
Total	8 x 4 = 32	3 x 2 = 06	4 x 4 = (16 Credits)	4 x 4 = (16 Credits)	3 x 4 + 1 x 6 = (18 Credits)	**23** (88 Credits)
	(38 Credits)					

13. **Multiple Entries and Multiple Exits:** The multiple entry and multiple exit features open up new opportunities for learners, even if they have stopped or discontinued their study in the middle for a variety of reasons. This feature provides entry options in order to promote flexible learning within the valid registration period (04 years from the date of admission to the PG programme). Learners only have the choice to leave the program at the end of even semester 02, and they have the option to reenter at the start of odd

semester 03. Only one exit option and reentry is permissible for MSc programme during stipulated time period.

14. **Exit Option- PG Diploma Certificate:** The learner who passes all registered courses of first year (two semesters) of the programme successfully in the examinations and obtains required credits (44 Credits), shall be awarded with Post Graduate Diploma Certificate PGD 11- PHY if learner shall opt for exit. The aggregate performance (SGPA of Semester 01 and Semester 02) and Class in the programme shall be reported on the basis of performance.
15. **PG Degree Certificate:** After successful completion of all courses (semesters 01 to 04) at two year of the programme and obtaining required credits (88 Credits), learner shall be awarded with Post Graduate Degree. The aggregate performance (CGPA of Semester 01 to Semester 04) and Class in the programme shall be reported on the basis of performance.
16. **Equivalence Status:** UGC and DEB recognized and approved [AY 2023 and onwards] with UGC/DEB letter F.No. 1-2/2021 (DEB-I), dated: 02.08.2021, available at https://www.ugc.ac.in/pdfnews/4204139_HEI-Recognition-list-02-08-2021.pdf

Eligibility and Fees

<table>
<tr><th>Admission

Eligibility</th><th>Certification

Eligibility</th><th colspan="3">Fees per Year
Annual Admission Form Amount (AAFA) is payable to university along with admission form at the start of each year.</th></tr>
<tr><td rowspan="6">Candidates with B.Sc. (PCM)/ B.Sc. Pass with Physics upto SY/B.Sc.(Electronics) /B.E./B. Tech.Degree or Equivalent pass</td><td rowspan="6">V151: Min 40% or better marks in total 23 courses (subjects) of total 88 credits at Semesters 01 to 04.

CGPA:
Aggregate performance and Class in the programme shall be reported on the basis of semesters 01 to 04.

For exit option PGD 11-PHY: Min 40% or better marks in total 12 courses (subjects) of total44 credits at Semesters 01 to 02.</td><td colspan="2">Description</td><td>INR ₹</td></tr>
<tr><td colspan="2"></td><td>1st Year</td><td>2nd Year</td></tr>
<tr><td colspan="2">Mandatory Fees</td><td>608</td><td>858</td></tr>
<tr><td rowspan="2">Tuition Fee</td><td>USF</td><td>8000</td><td>8000</td></tr>
<tr><td>LSCF</td><td>12000</td><td>12000</td></tr>
<tr><td colspan="2">End Exam Fees</td><td>2480</td><td>2370</td></tr>
<tr><td colspan="2">AAFA</td><td>23088</td><td>23228</td></tr>
</table>

Programme Structure

Year(2 Yr. PG)	Level/ Sem	Major				RM	OJT/ FP	RP	Cum. Cr.
		Mandatory (DSC)	**Cr**	**Elective (DSE)**	**Cr**				
I	6.0/ Sem I	PHY501: Classical Mechanics **(T)**	4	PHY506: Experimental Techniques in Physics **(T)** **OR** PHY 507: Physics of LASERs **(T)**	4	RES505: Research Methodology **(T) (4 Cr)**	-	-	22
		PHY502: Electronic Devices **(T)**	4						
		PHY503: Mathematical Methods in Physics **(T)**	2						
		PHY504: Physics I – Practical **(P)**	4						
	6.0/ Sem II	PHY509: Atomic and Molecular Physics **(T)**	4	PHY515: Fundamentals of Materials Science **(T)** **OR** PHY516: Medical Physics **(T)**	4	-	PHY513: OJT **(4 Cr)** **OR** PHY514: FP**(4 Cr)**	-	22
		PHY510: Electrodynamics **(T)**	4						
		PHY511:Quantum Mechanics-I **(T)**	2						
		PHY512: Physics II – Practical (Computational Methods using 'C' program) **(P)**	4						
Cum. Cr. For 1 Yrs PG Diploma		**28**		**8**		**4**	**4**	**-**	**44**
Exit option: PG Diploma (44 Credits) after Three Year UG Degree PGD 11-PHY: Post Graduate Diploma in Physics									
II	6.5/ Sem III	PHY601: Statistical Mechanics **(T)**	4	PHY606: Physics of Thin Film **(T)** **OR** PHY607: Astronomy and Astrophysics **(T)** **OR** PHY608: Energy Studies **(T)**	4	-	-	PHY605: Research Project **(4 Cr)**	22
		PHY602: Condensed Matter Physics **(T)**	4						
		PHY603: Quantum Mechanics - II **(T)**	2						
		PHY604: Physics III - Practical **(P)**	4						
	6.5/ Sem IV	PHY609: Nuclear and Particle Physics **(T)**	4	PHY613: Physics of Nano Materials **(T)** **OR** PHY614: General Relativity & Cosmology**(T)** **OR** PHY615: Energy from Waste **(T)**	4	-	-	PHY612: Research Project **(6 Cr)**	22
		PHY610: Electronic Instrumentation **(T)**	4						
		PHY611: Physics IV – Practical **(P)**	4						
Cum. Cr. For 2 Years PG Degree		**54**		**16**		**4**	**4**	**10**	**88**
2 Years-4 Sem. PG Degree (88 credits) after Three Year UG Degree									

Abbreviations: Yr.: Year; Sem.: Semester; Cr:Credits; Cumulative Credits: Cum. Cr. ; T- Theory Course; P- Practical course; TW-Term Work; PW- Project Work

Semesters and Courses

Abbreviations of the courses

Mandatory DSC	Discipline Specific Core Course	**Elective DSE**	Discipline Specific Elective Course
RM	Research Methodology	**OJT**	On Job Training: Internship/ Apprenticeship
FP	Field projects	**RP**	Research Project
OE	Open Elective (May be taken from MOOC or may be chosen from other domain of learning to get exposure to interdisciplinary domain)		

SN	Course Category	Code	Course Name	CA	EE	TM	Type	CR	Min %
[Level 6.0] Semester 01: 22 Credits									
01	Mandatory(DSC)	PHY501	Classical Mechanics	30	70	100	T	4	40%
02	Mandatory(DSC)	PHY502	Electronic Devices	30	70	100	T	4	40%
03	Mandatory(DSC)	PHY503	Mathematical Methods in Physics	15	35	50	T	2	40%
04	Mandatory(DSC)	PHY504	Physics I – Practical	50	50	100	P	4	40%
05	RM	RES505	Research Methodology	30	70	100	T	4	40%
Elective (DSE) Courses (Select Any One)									
06	Elective (DSE)	PHY506	Experimental Techniques in Physics	30	70	100	T	4	40%
07	Elective (DSE)	PHY507	Physics of LASERs	30	70	100	T	4	40%
[Level 6.0] Semester 02 : 22 Credits									
08	Mandatory(DSC)	PHY509	Atomic and Molecular Physics	30	70	100	T	4	40%
09	Mandatory(DSC)	PHY510	Electrodynamics	30	70	100	T	4	40%
10	Mandatory(DSC)	PHY511	Quantum Mechanics-I	15	35	50	T	2	40%
11	Mandatory(DSC)	PHY512	Physics II – Practical (Computational Methods using 'C' program)	50	50	100	P	4	40%
12	OJT/FP	PHY513 or PHY514	Any one OJT or FP	50	50	100	TW	4	40%
Elective (DSE) Courses (Select Any One)									
13	Elective (DSE)	PHY515	Fundamentals of Materials Science	30	70	100	T	4	40%
14	Elective (DSE)	PHY516	Medical Physics	30	70	100	T	4	40%
Exit option: PGD 11- PHY (44 Credits) after Three Year UG Degree									
[Level 6.5] Semester 03 : 22 Credits									
15	Mandatory(DSC)	PHY601	Statistical Mechanics	30	70	100	T	4	40%
16	Mandatory(DSC)	PHY602	Condensed Matter Physics	30	70	100	T	4	40%
17	Mandatory(DSC)	PHY603	Quantum Mechanics - II	15	35	50	T	2	40%

18	Mandatory(DSC)	PHY604	Physics III - Practical	50	50	100	P	4	40%
19	RP	PHY605	Research Project	50	50	100	PW	4	40%
Elective (DSE) Courses (Select Any One)									
20	Elective (DSE)	PHY606	Physics of Thin Film	30	70	100	T	4	40%
21	Elective (DSE)	PHY607	Astronomy and Astrophysics	30	70	100	T	4	40%
22	Elective (DSE)	PHY608	Energy Studies	30	70	100	T	4	40%
[Level 6.5] Semester 04 : 22 Credits									
23	Mandatory(DSC)	PHY609	Nuclear and Particle Physics	30	70	100	T	4	40%
24	Mandatory(DSC)	PHY610	Electronic Instrumentation	30	70	100	T	4	40%
25	Mandatory(DSC)	PHY611	Physics IV – Practical	50	50	100	P	4	40%
26	RP	PHY612	Research Project	75	75	150	PW	6	40%
Elective (DSE) Courses (Select Any One)									
27	Elective (DSE)	PHY613	Physics of Nano Materials	30	70	100	T	4	40%
28	Elective (DSE)	PHY614	General Relativity & Cosmology	30	70	100	T	4	40%
29	Elective (DSE)	PHY615	Energy from Waste	30	70	100	T	4	40%
2 Years- 4 Semester PG Degree in Physics (88 credits) after Three Year UG Degree									

Grading System

1. "**Absolute Grading**": the marks are converted to grades based on pre-determined class intervals.
2. "**Letter Grade**": It is an index of the performance of students in a said programme. Grades are denoted by letters O, A+, A, B+, B, C, P and F.
3. "**Grade Point**": It is a numerical weight allotted to each letter grade on a 10-point scale. Grade Point shall be "0 (Zero)" for Letter Grade "Ab" and "F". The marks scored by the examinee shall be converted into grade points by dividing the marks scored in the aggregate and dividing the resulting number by maximum marks, multiplying the result by ten, retaining the integer part (ignore the fractional part). Thus, if a person has secured 56 marks out of 100 marks in aggregate for a course, we get (56/100) x 10 which is 5.6. Ignoring the fraction, we get 5 as the grade point.

Marks Obtained out of 100	Grade Point	Semester GPA / Programme CGPA/ Semester/Programme	% of Marks	Alpha-Sign / Letter Grade Result
90 - 100	10	9.00 – 10. 00	90.0 - 100	O (Outstanding)
80 – 89.99	9	8.00 - < 9.00	80.0 - < 90.0	A+ (Excellent)
70 – 79.99	8	7.00 - < 8.00	70.0 - < 80.0	A (Very Good)
60 – 69.99	7	6.00 - < 7.00	60.0 - < 70.0	B+ (Good)
55 – 59.99	6	5.50 - < 6.00	55.0 - < 60.0	B (Above Average)
50 – 54.99	5	5.00 - < 5.50	50.0 - < 55.0	C (Average)
40 – 49.99	4	4.00 - < 5.00	40.0 - < 50.0	**P (Pass)**
0 – 39.99	0	Below 4.00	**Below 40**	**F (Fail)**
		Ab (Absent)	**-**	**Absent**

4. "**Credit Point**": It is the product of grade point and number of credits for a course.

5. "**Semester Grade Point Average (SGPA)**": It is a measure of performance of work done in a semester. It is the ratio of sum of the product of the number of credits with the grade points scored by a student in all courses takenby a student and the sum of number of credits of all the courses undergone by a student:

$$SGPA\ (S_i) = \frac{\sum C_i G_i}{\sum C_i}$$

It shall be expressed up to two decimal places.

6. "**Cumulative Grade Point Average (CGPA)**": It is a measure of overall cumulative performance of a student over all semesters. The CGPA is the ratio of total credit points secured by a student in various courses in all semesters and the sum of the total credits of all courses in all the semesters.The CGPA is also calculated in the same manner taking into account all the courses undergone by a student over all the semesters of a programme.

$$CGPA = \frac{\sum C_i S_i}{\sum C_i}$$

Where, $S_i$is theSGPAof the ith semester &$C_i$is the total number of credits in that semester.

It shall be expressed up to two decimal places.

7. "**Transcript or Grade Card or Certificate**": Based on the grades earned, a grade certificate shall be issued to all the registered students after every semester. The grade certificate will display the course details (code, title, number of credits, grade secured) along with SGPA of that semester and CGPA earned till that semester.

8. **"Evaluation Pattern**": As per NEP2020, the 'Evaluation Pattern' of the Post graduate Programme consists of the following components:

Course Type	Number of Credits	Continuous Assessment (CA)	End Examination (EE)	Total Marks 'TM' = (CA+EE)	Minimum Passing %
Theory(T)	4	30	70	100	minimum 40% in CA, EE and (CA + EE) shall be essential for each course to pass
Theory (T)	2	15	35	50	
Practical (P)	4	50	50	100	
OJT/Field Project (FP)	4	50	50	100	
Research Project (RP)	4	50	50	100	
Research Project(RP)	6	75	75	150	

Evaluation Pattern

[CA and EE Evaluation Pattern as per the Minutes of the Meeting of the NEP Cell Dated 21.11.2023]

SN	Type of Course	Continuous Assessment (CA)	End Examination (EE)
1	Theory (T) 4 Credit 100 Marks CA: 30% EE: 70%	Each student is required to attempt total 02 (Two) "Continuous Assessments (CAs)" for each course of each Semester, as per the following details: 1. CA01: 'Continuous Assessment 01 (CA01)' on Credit 01 to Credit 04 of each course, consists of • 2 (Two) 'Short Answer Questions (SAQs)' of 5 Marks, on Credit 01 and Credit 02 **and** • 1 (One) 'Long Answer Question (LAQ)' of 10 Marks, on Credit 03 and Credit 04. LAQ may consist of sub-questions. **CA01**: On Credit 01 to Credit 04, of Marks = (5x2 + 10) = **20 Marks** 2. CA02: 'Continuous Assessment 02 (CA02)' on Credit 01 to Credit 04 of each course, consists of • A test containing total **10** (Ten) 'Objective Type Questions, ' 05 (Five) on Credit 01 and Credit 02, and 05 (Five) on Credit 03 and Credit 04. Each 'Objective Type Question' of 1 Mark. **CA02**: On Credit 01 to Credit 04, of Marks = **10 Marks** 3. Maximum number of attempts for **CA,** during each semester : Single attempt only 4. **Total Marks**: **30** Marks	1. Student is required to answer **05 'VSAQs' out of 06 'VSAQs'**, each carrying 03 Marks, on Credit 01 to 04, for total 15 Marks. One VSAQ will be on each Credit. 2. Student is required to answer **05 'SAQs' out of 06 'SAQs'**, each carrying 05 Marks, on Credit 01 to 04, for total 25 Marks. One SAQ will be on each Credit. 3. Student is required to answer **01 'LAQ' out of 2 LAQs,** of 10 Marks on Credit 01 and Credit 02, for total 10 Marks. LAQ may consist of sub-questions. 4. Student is required to answer **01 'LAQ' out of 2 LAQs,** of 10 Marks on Credit 03 and Credit 04, for total 10 Marks. LAQ may consist of sub-questions. 5. Student is required to answer **01 'LAQ' out of 2 LAQs,** of 10 Marks on Credit 01 to Credit 04, for total 10 Marks. LAQ may consist of sub-questions. 6. Number of attempts: Till Valid Registration Period (VRP) only 7. Marks: 70 Marks 8. Duration: 150 minutes

<table>
<tr><th>SN</th><th>Type of Course</th><th colspan="2">Continuous Assessment (CA)</th><th>End Examination (EE)</th></tr>
<tr><td></td><td></td><td colspan="2"><table>
<tr><th>SN</th><th>Description</th><th>Evaluation of End Examination(EE)</th><th>Marks</th></tr>
<tr><td rowspan="3">1</td><td rowspan="3">Question Types</td><td>Very Short Answer Question (VSAQ) on each Credit</td><td>03 Marks</td></tr>
<tr><td>Short Answer Question (SAQ) on each Credit</td><td>05 Marks</td></tr>
<tr><td>On each Credit, either Single Long Answer Question (LAQ) or LAQ contains sub-questions (a), (b) and so on.</td><td>10 Marks</td></tr>
<tr><td>2</td><td>Grand Total Marks</td><td>Total five Questions in EE Question paper based on:
Credit 01 to 04 : 05 VSAQs out of 06 VSAQs (15 Marks)
Credit 01 to 04 : 05 SAQs out of 06 SAQs (25 Marks)
Credit 01 to 02 : 01 LAQ out of 02 LAQs (10 Marks)
Credit 03 to 04 : 01 LAQ out of 02 LAQs (10 Marks)
Credit 01 to 04 : 01 LAQ out of 02 LAQs (10 Marks)
LAQ may contains sub-questions</td><td>70 Marks</td></tr>
</table></td><td></td></tr>
<tr><td>2</td><td>Theory (T)

2 Credit
50 Marks

CA: 30%
EE: 70%</td><td colspan="2">Each student is required to attempt total 01 (One) “Continuous Assessment (CA)” for each course of each Semester, as per the following details:
1. CA01: 1 (One) ‘Continuous Assessment 01 (CA01)’ on Credit 01 and Credit 02 of each course, consists of
• 1 (One) ‘Short Answer Question (SAQ)’ of 5 Marks
and
• 1 (One) ‘Long Answer Question (LAQ)’of 10 Marks, LAQ may consist of sub-questions.
CA01: On Credit 01 and Credit 02, of Marks = (5 + 10) = 15 Marks
2. Maximum number of attempts for CA, during each semester: Single attempt only
3. Total Marks: 15 Marks</td><td>1. Student is required to answer 05 ‘VSAQs’ out of 06 ‘VSAQs’, each carrying 03 Marks, on Credit 01 to 02, for total 15 Marks. One VSAQ will be on each Credit.
2. Student is required to answer 02 ‘SAQs’ out of 03 ‘SAQs’, each carrying 05 Marks, on Credit 01 to 02, for total 10 Marks. One SAQ will be on each Credit.
3. Student is required to answer 01 ‘LAQ’ out of 2 LAQs, of 10 Marks on Credit 01 and Credit 02, for total 10 Marks. LAQ may consist of sub-questions.
4. Number of attempts: Till Valid Registration Period (VRP) only
5. Marks: 35 Marks
6. Duration: 75 minutes</td></tr>
<tr><td></td><td></td><td colspan="2"><table>
<tr><th>SN</th><th>Description</th><th>Evaluation of End Examination (EE)</th><th>Marks</th></tr>
<tr><td rowspan="3">1</td><td rowspan="3">Question Types</td><td>Very Short Answer Question (VSAQ) on each Credit</td><td>03 Marks</td></tr>
<tr><td>Short Answer Question (SAQ) on each Credit</td><td>05 Marks</td></tr>
<tr><td>On each Credit, either Single Long Answer Question (LAQ) or LAQ contains sub-questions (a), (b) and so on.</td><td>10 Marks</td></tr>
<tr><td>2</td><td>Grand Total Marks</td><td>Total three Questions in EE Question paper based on:
Credit 01 to 02 : 05 VSAQs out of 06 VSAQs (15 Marks)
Credit 01 to 02 : 02 SAQs out of 03 SAQs (10 Marks)
Credit 01 to 02 : 01 LAQ out of 02 LAQs (10 Marks)
LAQ may contains sub-questions</td><td>35 Marks</td></tr>
</table></td><td></td></tr>
</table>

<table>
<tr><th>SN</th><th>Type of Course</th><th>Continuous Assessment (CA)</th><th>End Examination (EE)</th></tr>
<tr><td>3</td><td>Practical (P)

4 Credit
100 Marks

CA: 50%
EE: 50%</td><td>1. Student is required to submit “Activity Report in Work-Book Format” for each Credit in the prescribed format.
2. Maximum number of attempts for each CA, during each semester : Single attempt only
3. Marks: 50 Marks
4. Grading criteria:
<table>
<tr><td>Lab Punctuality, Preparedness & Ethics</td><td>Irregular in lab. Copies the experiment from others
(0 Points)</td><td>Consistently regular but unable to explain the concepts
(06 Points)</td><td>Punctuality in lab. Follows the procedure and responds to questions asked
(10 Points)</td></tr>
<tr><td>Activity Report and Performance

(Experiment No, Date, Objectives, Apparatus with specification, Observations, Graphs, software used if any)</td><td>Poor Documentation and copied the experiment from others.
Couldn't perform the Activity /poor observation made
(04 Points)</td><td>Average Documentation : Report is in format but some of the formatting guidelines are missed. Performed the Activity but observations made with some mistakes
(12 Points)</td><td>Good Documentation: Lab activity writing is in proper format with all references, Grammar.
Performed the Activity on time observations made with no mistakes
(20 Points)</td></tr>
<tr><td>Results and Conclusion</td><td>Unable to achieve the desired results but makes attempts to relate data to theory. Poor concluding statements
(08 Points)</td><td>Average graphical and tabulated representation with misinterpret physical significance of theory. Achieve the desired results and but insufficient conclusion statement.
(14 Points)</td><td>Analyses and interpret observed data carefully with good graphical and tabulated representation using appropriate theory/evidence. Achieve the results and reach to appropriate Conclusion
(20 Points)</td></tr>
</table>
</td><td>External and internal examiners shall assess each student based on:
1. Workbook/Activity Report submission by the student (Only by External Examiner) [05 Marks]
2. Practical Activity performed by the student [12 Marks]
3. Result and Conclusion of the Practical Activity [13 Marks]
4. Viva-Voce on Practical Activities [20 Marks]
5. Number of attempts: Till Valid Registration Period (VRP) only
6. Marks: 50 Marks
7. Duration: 180 minutes</td></tr>
</table>

SN	Evaluation of Practical End Examination		
	Description	Internal Examiner	External Examiner
1	Workbook/Activity Report	-	05 Marks
2	Actual Conduct of one randomly selected Practical Activity	02 Marks	10 Marks
3	Diagram, Synoptic Answers, Graph/Observation and Conclusion	03 Marks	10 Marks
4	Viva-Voce/Oral	05 Marks	15 Marks
5	Total	10 Marks	40 Marks

<table>
<tr><th>SN</th><th>Type of Course</th><th>Continuous Assessment (CA)</th><th>End Examination (EE)</th></tr>
<tr><td>4</td><td>Field Project (TW)

4 Credit
100 Marks

CA: 50%
EE: 50%</td><td>Students need to complete one month Field Project (Total Study hours 120 hrs including Activity Report). After completion of the field project, learners shall submit a report to the LSC - Programme Coordinator (PC) and Mentor/Guide.
1. Maximum number of attempts for each CA, during each semester: Single attempt only
2. Duration: 1 Month or 4 Weeks duration – i) After end examination of semester 02 and before beginning of semester 03 or
ii) Any one month during semester 02 duration
3. Marks: 50 Marks
4. Grading Criteria for Evaluation of FP (only by Mentor/Guide):
<table>
<tr><th>SN</th><th>Description</th><th>Marks</th></tr>
<tr><td>1</td><td>Key Definitions of Problem area and analysis of preliminary data</td><td>15</td></tr>
<tr><td>2</td><td>Work related to formats, Correspondence, Interactions and liaising etc</td><td>05</td></tr>
<tr><td>3</td><td>Field work and data collection</td><td>15</td></tr>
<tr><td>4</td><td>Analysis and Report</td><td>10</td></tr>
<tr><td>5</td><td>Feedback to community</td><td>05</td></tr>
<tr><td colspan="2">Total</td><td>50</td></tr>
</table></td><td>1. External and Internal examiners (Internal examiner - Programme Coordinator (PC) / Supervisor of LSC) shall assess each student based on:
a. Activity Report submission by the student (Only by External Examiner) [10 Marks]
b. Viva-Voce on Activity Report [40 Marks]
2. Number of attempts: Till Valid Registration Period (VRP) only
3. Marks: 50 Marks
4. Duration: 180 minutes</td></tr>
<tr><td colspan="4">
<table>
<tr><th rowspan="2">SN</th><th colspan="3">Evaluation of Field Project End Examination</th></tr>
<tr><th>Description</th><th>Internal Examiner
(Programme Coordinator (PC)/ Supervisor of LSC)</th><th>External Examiner</th></tr>
<tr><td>1</td><td>Workbook/Report submission</td><td>-</td><td>10 Marks</td></tr>
<tr><td>2</td><td>Viva-Voce /Oral</td><td>10 Marks</td><td>30 Marks</td></tr>
<tr><td>3</td><td>Total</td><td>10 Marks</td><td>40 Marks</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>SN</th><th>Type of Course</th><th>Continuous Assessment (CA)</th><th>End Examination (EE)</th></tr>
<tr><td>5</td><td>OJT or Internship (TW)

4 Credit
100 Marks

CA: 50%
EE: 50%</td><td>
1. Students need to complete one month On Job Training (OJT) or Internship (Total Study hours 120 hrs including Internship Report) in any Industry/Organization/Institute/ R&D Division /Any Micro/Small/Medium/enterprise/Govt/NGO/PSU/Online Internship related to major course.
2. Maximum number of attempts for each CA, during each semester: Single attempt only
3. Marks: 50 Marks
4. Duration: 1 Month or 4 Weeks –
i) After end examination of semester 02 and before beginning of semester 03.
or
ii) Any one month during semester 02 duration
5. Grading Criteria for Evaluation of OJT (or Intern) only by Mentor where the Internship is proposed to be imparted:
<table>
<tr><th>SN</th><th>Parameters</th><th>Marks Out of</th></tr>
<tr><td>1</td><td>Behaviors, Shows interest in assigned work, Willingness to learn</td><td>10</td></tr>
<tr><td>2</td><td>Accepts responsibility, Cooperates with co-workers and supervisors, Demonstrates organizational skills</td><td>10</td></tr>
<tr><td>3</td><td>Uses time, knowledge and expertise effectively, Analyzes problems effectively</td><td>10</td></tr>
<tr><td>4</td><td>Demonstrates creativity/ originality / any innovative contribution, Professional ethics and accountability</td><td>10</td></tr>
<tr><td>5</td><td>Writes effectively, Produces high quality work/Skill Proficiency</td><td>10</td></tr>
<tr><td colspan="2">Total</td><td>50</td></tr>
</table>
Document as Evidence: Activity report along with Certificate or Declaration, duly issued and signed by the concerned authority [To be assessed during EE] should be submitted during End Examination to the parent Learner support Centre (LSC).
</td><td>
At the end of second semester, Programme Coordinator (PC)/ Supervisor of LSC and 1 (one)External Examiner will complete ‘End Exam (EE)’ for all allotted students as follows:
1. Duration of EE: After Theory EE of second Semester
2. Programme Coordinator (PC)/ Supervisor of LSC and External Expert will have 20% and 80% weightage respectively in EE.
3. Number of attempts: Till Valid Registration Period (VRP) only
4. Marks for EE: 50 Marks
<table>
<tr><th>Parameter</th><th>PC /Supervisor of LSC</th><th>External Expert</th></tr>
<tr><td>Professional Attitude</td><td>-</td><td>05 Marks</td></tr>
<tr><td>Maintenance of Daily Diary</td><td>-</td><td>10 Marks</td></tr>
<tr><td>Internship Report</td><td>05 Marks</td><td>10 Marks</td></tr>
<tr><td>Viva/Oral</td><td>05 Marks</td><td>15 Marks</td></tr>
<tr><td>Total</td><td>10 Marks</td><td>40 Marks</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>SN</th><th>Type of Course</th><th>Continuous Assessment (CA)</th><th>End Examination (EE)</th></tr>
<tr><td>6</td><td>Project Work (PW)

RP-I
4 Credit
100 Marks

CA: 50%
EE: 50%</td><td>1. Student is required to submit “Activity Report” based on Grading Criteria of the course in the prescribed format.
2. Maximum number of attempts for each CA, during each semester: Single attempt only
3. Marks: 50 Marks
4. Grading Criteria:
<table>
<tr><th>SN</th><th>Desc</th><th>Marks</th></tr>
<tr><td>1</td><td>Seminar*</td><td>25</td></tr>
<tr><td>2</td><td>Research Proposal</td><td>25</td></tr>
</table>
*To be conducted in Online/Offline mode at LSC.</td><td>1. External and internal examiners shall assess each student based on:
a. Project Report submission by the student (Only by External Examiner) [10 Marks]
b. Project Presentation by the student [20 Marks]
c. Viva-Voce on Project Report [20 Marks]
2. Number of attempts: Till Valid Registration Period (VRP) only
3. Marks: 50 Marks
4. Duration: 180 minutes</td></tr>
<tr><td colspan="4">
<table>
<tr><th rowspan="2">SN</th><th colspan="3">Evaluation of Project Work End Examination</th></tr>
<tr><th>Description</th><th>Internal Examiner</th><th>External Examiner</th></tr>
<tr><td>1</td><td>Project Report</td><td>-</td><td>10 Marks</td></tr>
<tr><td>2</td><td>Project Presentation</td><td>05 Marks</td><td>15 Marks</td></tr>
<tr><td>3</td><td>Viva-Voce /Oral</td><td>05 Marks</td><td>15 Marks</td></tr>
<tr><td>4</td><td>Total</td><td>10 Marks</td><td>40 Marks</td></tr>
</table>
</td></tr>
<tr><td>7</td><td>Project Work (PW)

RP-II

6 Credit
150 Marks

CA: 50%
EE: 50%</td><td>1. Student is required to submit “Activity Report” based on Grading Criteria of the course in the prescribed format.
2. Maximum number of attempts for each CA, during each semester: Single attempt only
3. Marks: 75 Marks
4. Grading Criteria:
<table>
<tr><th>SN</th><th>Desc</th><th>Marks</th></tr>
<tr><td>1</td><td>Seminar*</td><td>30</td></tr>
<tr><td>2</td><td>Research Paper Presentation**</td><td>30</td></tr>
<tr><td>3</td><td>Project Report</td><td>15</td></tr>
</table>
*To be conducted in Online/Off line mode at LSC.
** Journals/Conferences/ at LSC, in Online/Offline mode [This activity shall be organized by respective LSC in Online/Offline mode in case student didn’t get an opportunity for presentation at Journals/Conferences]</td><td>1. External and internal examiners shall assess each student based on:
a. Project Report submission by the student (Only by External Examiner) [20 Marks]
b. Project Presentation by the student [25 Marks]
c. Viva-Voce on Project Report [30 Marks]
2. Number of attempts: Till Valid Registration Period (VRP) only
3. Marks: 75 Marks
4. Duration: 180 minutes</td></tr>
</table>

SN	Type of Course	Continuous Assessment (CA)	End Examination (EE)

SN	Evaluation of Project Work End Examination		
	Description	Internal Examiner	External Examiner
1	Project Report	-	20 Marks
2	Project Presentation	05 Marks	20 Marks
3	Viva-Voce /Oral	10 Marks	20 Marks
	Total	15 Marks	60 Marks

1. **Separate and independent passing @ 40% in CA, EE and (CA+EE) shall be essential for each course - Theory, Practical, OJT/FP and RP.** "CA, EE and Total marks" shall be separately reported for each course in the transcript or mark-statement. The minimum and maximum marks for "CA, EE and Total Marks" are shown in the table below. If student does not score a minimum of 40% marks in CA or in EE of a course then the result of such a course will be reported as FAIL.

Course Type	Number of Credits	Continuous Assessment (CA)		End Examination(EE)		Total Marks 'TM' = (CA +EE)	
		Min	**Max**	**Min**	**Max**	**Min**	**Max**
Theory	2	6	15	14	35	20	50
	4	12	30	28	70	40	100
Practical/ OJT/FP/RP	4	20	50	20	50	40	100
	6	30	75	30	75	60	150

2. In each semester, only 1 attempt, for CA for each course and for EE for each course shall be allowed. Only during valid registration period (VRP), students are allowed to appear for CA and EE for each course against the payment of the specified 'Examination Fee' for each attempt, for each course where he/she is admitted by the university. The 'CA and/or EE' attempts are counted for each examination option offered by the university to the student, irrespective of whether student actually chooses to appear in end exam or not.

3. If a student does not successfully complete the continuous assessment (CA) or pass the End Examination of Practical/Term work/OJT/Field Project/Research Project courses, they may complete these requirements with the next semester at the respective Learning Support Center (LSC) only during the valid registration period (VRP).

4. Duration for Practical/Term work/OJT/Field Project/Research Project type of Courses: 180 Minutes for a batch of typically 15 ± 3 students

5. Only best of past performance shall be reported in transcript or mark statement.

6. **Total student evaluation for**

   a. **Each** semester shall be for **550** marks
   b. **Each** year shall be for **1100** marks
   c. **Each** regular PG degree shall be for **2200** marks

7. **Reporting Semesters** for certification:

    - Min 40% or better marks in total 23 courses (subjects) of total 88 credit points at Semesters 01-04.

Successful Completion of Course or Programme

1. "Successful Completion of the Course" means - either course is exempted or student gets minimum specified or better grade, either in end examination of that course or by credit transfer. A student obtaining grade “F” shall be considered failed and will be required to reappear in the examination. The student obtained minimum “P” (Pass) letter grade required for successful completion of each course.
2. "Successful Completion of the Programme" means – all courses at all semesters are successfully completed and the student obtained “P” (Pass) letter grade for all courses at all semesters along with minimum specified SGPA and CGPA.

SEMESTER 01

PHY501: CLASSICAL MECHANICS

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics){2023 Pattern} & V141: M.Sc. (Physics){2022 Pattern}

COURSE INFORMATION

Sem	Major	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
01	DSC	PHY501	Classical Mechanics	4	12	120	30	70	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully completed: • Candidates with B.Sc./ B.Sc.(Physics)/B.Sc.(Electronics)/B. E./B. Tech Degree or Equivalent pass	This course enables the students: • Explain the concepts of Langrangian approach and its applications in Classical Mechanics. • Interpret the concepts of Hamiltonian Mechanics and its applications. • Explain generating function, canonical transformation & Poisson brackets. • Illustrate the dynamics of a rigid body and non-inertial frames of reference.

UNITS

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	Mechanics of a System of Particles D'Alembert's Principle and Lagrange's Equations Central Force Motion Kepler's Laws and Virial Theorem	CR 01	As per evaluation pattern, on Each Credit, Student is required to answer • Very Short Answer Question (VSAQ), of 03 marks • Short Answer Question (SAQ), of 05 marks • Long Answer Question (LAQ) of 10 Marks (LAQ may contain sub-questions (a), (b) and so on.)
02-01 02-02 02-03 02-04	Calculus of Variation Euler's Equation and its Applications Hamilton's Principle Hamilton's Equation of Motion	CR 02	
03-01 03-02 03-03 03-04	Routh Procedure and the Least Action Principle Canonical Transformations Invariance under Canonical Transformations Lagrange and Poission Brackets	CR 03	
04-01 04-02 04-03 04-04	Rigid Body Motion-Rotations in Plane and Space The Euler Angles A Moving Coordinate Frame Rotational Dynamics of a Rigid Body	CR 04	

DETAILED SYLLABUS

UN	Detailed Syllabus of the Unit	CR
1-1	**Mechanics of a System of Particles:** Mechanics of a particle, Mechanics of a system of particles, Degrees of freedom and generalized coordinates.	CR 01
1-2	**D'Alembert's Principle and Lagrange's Equations:** D'Alembert's principle, Derivation of Lagrange's equations for conservative system, Generalized potential, Rayleigh's dissipation function	
1-3	**Central Force Motion:** Equivalent one body problem, Central force field, Motion in one dimension, Classification of central orbits, Differential equation for the orbit, Integrable power law force field	
1-4	**Kepler's Laws and Virial Theorem:** Kepler's first law, Kepler's second law, Kepler's third law, Virial theorem	
2-1	**Calculus of Variation:** Preliminaries, Functional, Continuity of a functional	CR 02
2-2	**Euler's Equation and its Applications:** Variation of y(x) and I[y(x)], An elementary problem in the CV, Invariance of Euler equation, Applications of Euler equation.	
2-3	**Hamilton's Principle:** Hamilton's principle for conservative system, Extension of Hamilton's principle to non-conservativeholonomic system, Lagrange's equation for nonholonomic conservative systems.	
2-4	**Hamilton's Equation of Motion:** Derivation of the Hamilton's canonical equations, Hamilton's equations from variational principle.	
3-1	**Routh Procedure and the Least Action Principle:**Routhian of a mechanical system, The least action principle.	CR 03
3-2	**Canonical Transformations:** Some transformations, Canonical or contact transformations, Generating function of a canonical transformation.	
3-3	**Invariance under Canonical Transformations:** Bilinear covariant of the Pfaffian differential form, Theorem of Poincare, Infinitesimal canonical transformation	
3-4	**Lagrange and Poission Brackets:** Lagrange bracket, Poisson bracket, Equations of motion in Poisson bracket, Canonical invariance of the Poisson bracket, Jacobi identity, Angular momentum and Poisson brackets, Relation between Lagrange and Poisson brackets	
4-1	**Rigid Body Motion-Rotations in Plane and Space:** Preliminaries, Rotations in the plane, Rotations in 3-space.	CR 04
4-2	**The Euler Angles:** Transformation matrix in terms of Euler angles, The Euler's theorem, Finite rotations, Infinitesimal rotations.	
4-3	**A Moving Coordinate Frame:** Translational accelerated frame, A rotating coordinate frame, Acceleration in a rotating system, Application to the rotating earth	
4-4	**Rotational Dynamics of a Rigid Body:** Mathematical back ground, Angular momentum and inertia tensor, Principal axes, The Euler equations of motion.	

LEARNING RESOURCE DETAILS

LR Code	Title	Edition	ISBN

	Author	Year	Publisher
Text-Books			
PHY501-T01	Classical Mechanics	2022	YCMOU, Nashik
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
PHY501: RB1	Classical Mechanics, Dr. T.M. Karade	2019	978-9391514365
PHY501: RB2	Classical Mechanics, Herbert Goldstain	2000	
PHY501: RB3	Classical Mechanics, Dr. J. C. Upadhaya	2019	
PHY501: RB4	Classical Mechanics, G. Aruldhas	2008	978-8-20333314
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
PHY502 - CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
PHY502-WL1			

Course Outcomes

After successful completion of this course, student should be able to

- Describe the laws governing the motion of a system of particles.
- Define Lagrange's equations of motion.
- Explain the role played by Hamilton's principle in classical mechanics
- Explain the function Routhian like the Lagrangian and the Hamiltonian
- Describe the role of canonical transformations in Hamitonian mechanics
- Clarify the rotations in a plane and space
- Underastand variational principles to real physical problems

PHY502: ELECTRONIC DEVICES

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics) {2023 Pattern} & V141: M.Sc. (Physics){2022 Pattern}

COURSE INFORMATION

Sem	Major	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
01	DSC	PHY502	Electronic Devices	4	12	120	30	70	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully completed: • Candidates with B.Sc. / B.Sc.(Physics)/B.Sc.(Electronics)/ B.E./B. Tech Degree or Equivalent pass	This course enables the students: • Impart knowledge about a variety of analog and digital electronic devices, their structure and the underlying physical principles. • Gain a deeper understanding of linear and digital electronic circuits, to be able to conceptualize, implement and actualize both linear and digital electronics circuits. • Study the applications of electronic devices with circuit diagram

UNITS

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	Study of Timer IC 555 Study of VCO IC 566 Study of PLL IC 565 Function generator using two OPAMPs with variable controls	CR 01	As per evaluation pattern, on Each Credit, Student is required to answer • Very Short Answer Question (VSAQ), of 03 marks • Short Answer Question (SAQ), of 05 marks • Long Answer Question (LAQ) of 10 Marks (LAQ may contain sub-questions (a), (b) and so on.)
02-01 02-02 02-03 02-04	Voltage Regulator Three pin regulators IC 723 DC - DC converter	CR 02	
03-01 03-02 03-03 03-04	Boolean Algebra and Logic Families Digital Logic circuits: Sequential Logic Counter Shift registers using IC 7495	CR 03	
04-01 04-02 04-03 04-04	Digital to analog converters Study of IC 0808 Analog to digital converters Study of ICL 7106	CR 04	

DETAILED SYLLABUS

UN	Detailed Syllabus of the Unit	CR

1-1	**Study of Timer IC555:** Block diagram, Astable,bistable and monostablemultivibrator	**CR 01**
1-2	**Study of VCO IC566:** VCO IC566 Circuit diagramand its explanation,	
1-3	**Study of PLL IC 565 :** Block diagram, applications like frequency multiplier, FSK, FM demodulator	
1-4	**Function generator using two OPAMPs with variable controls:** Function generator using two OPAMPs with variable controlsAstable, andmonostablemultivibrators using OPAMP	
2-1	**Voltage Regulator**:series and shunt regulators,CV, CC, SMPS.	**CR 02**
2-2	**Three pin regulators**: (IC 78XX/79XX, IC LM 317).	
2-3	**IC 723:**Basic low and high voltage regulator and feedback current limiting using IC 723.	
2-4	**DC - DC converter**: Concept and applications of DC - DC converter	
3-1	**Boolean Algebra and Logic Families:**Review of Boolean identities and its use to minimize Boolean Expressions, Minimization of Boolean expressions using Karnaugh map(upto 4 variables).	**CR 03**
3-2	**Digital Logic circuits: Sequential Logic:**Review of synchronous, asynchronous and combinational counters (4-bit).	
3-3	**Counter**: Decade counter IC 7490 with applications.	
3-4	**Shift registers using IC 7495 :** applications as SISO, SIPO, PISO and PIPO, Up-down counter	
4-1	**Digital to analog converters:** Binary weighted type, R-2R ladder type	**CR 04**
4-2	**Study of IC 0808:** Pin configuration, Application	
4-3	**Analog to digital converters:** Single slope, Dual slope, Flash, Counter type, Continuous type, Simultaneous type, Successive approximation type	
4-4	**Study of ICL 7106:** Study of ICL 7106/ ICL7107-3 & ½ Digit A/D Converters	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Text-Books			
PHY502-T01	Electronic Devices - Dr. Chetana Kamlaskar	2022	978-9395855068 YCMOU, Nashik
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
PHY502: RB1	Operational Amplifiers - G. B. Clayton	5th edition	
PHY502: RB2	OPAMPS and Linear Integrated Circuits - Ramakant Gayakwad,		Prentice Hall
PHY502: RB3	Linear Integrated Circuits - D. Roy Choudhary, Shail Jain		
PHY502: RB4	Electronic Principles - A. P. Malvino,		TMH
PHY502: RB5	Power Supplies - B. S. Sonde		
PHY502: RB6	SMPS, Inverters, Converters - Gottlieb		

PHY502: RB7	Digital Principles and Applications - Leach and Malvino		
PHY502: RB8	Digital Electronics -R. P. Jain		
PHY502: RB9	Data Converters -B. S. Sonde		
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
PHY503-CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
PHY503-WL1			

Course Outcomes

After successful completion of this course, student should be able to

- Explain structure and working principles of few important analog and digital electronics devices.
- Explain the characteristics, working principle and applications of Timer IC, VCO, PLL
- Characterized the types of Power Supply, ADC, DAC and Logic Families

PHY503:MATHEMATICAL METHODS IN PHYSICS

Programme Information

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics){2023 Pattern} & V141: M.Sc. (Physics){2022 Pattern}

Course Information

Sem	Major	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
01	DSC	PHY503	Mathematical Methods in Physics	2	06	60	15	35	50	T

Presumed Knowledge and Learning Objectives

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully completed: • Candidates with B.Sc./ B.Sc.(Physics)/B.Sc.(Electronics)/ B.E./B. Tech Degree or Equivalent pass	This course enables the students: • To develop required mathematical skills to solve problems in quantum mechanics, electrodynamics and other fields of theoretical physics. • To study mathematical methods used in physics such as non-homogeneous differential equation of higher order, Fourier Transform, Inverse Fourier Transform & their applications

UNITS

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	Linear Equations with Constant Coefficients Dependence and independence of solutions Applications of Second Order Linear Equations The homogeneous equation of higher order	CR 01	As per evaluation pattern, on Each Credit, Student is required to answer • Very Short Answer Question (VSAQ), of 03 marks • Short Answer Question (SAQ), of 05 marks • Long Answer Question (LAQ) of 10 Marks (LAQ may contain sub-questions (a), (b) and so on.)
02-01 02-02 02-03 02-04	Fourier Integrals Fourier Transforms Inverse Fourier Transforms Applications of Fourier Transforms	CR 02	

DETAILED SYLLABUS

UN	Detailed Syllabus of the Unit	CR

1-1	**Linear Equations with Constant Coefficients:** Introduction, The second order homogeneous equation Initial value problems for second order equations, Uniqueness theorem	**CR 01**
1-2	**Dependence and independence of solutions:** Linear dependence and independence, A formula for the Wronskian, The non-homogeneous equation of order two.	
1-3	**Applications of Second Order Linear Equations:** Hooke's Law, Force acting upon the mass, Free, damped and undamped motion and Electric circuit problems	
1-4	**The homogeneous equation of higher order**: Initial value problems for *nth* order equations, Existence and uniqueness theorems, Equations with real constants	
2-1	**Fourier Integrals:** Preliminaries of Special Functions such as the Gamma, Error and Bessel functions, Fourier Integral Representations, Proof of the Fourier Integral Theorem.	**CR 02**
2-2	**Fourier Transforms**: Fourier Transform Pairs, Properties of the Fourier Transform, Fourier Cosine and Sine Transforms, Transforms of More Complicated Functions.	
2-3	**Inverse Fourier Transforms**: Inverse Fourier Transform, Inverse Fourier Sine Transform, Inverse Fourier Cosine Transform, Modulation Theorem, Convolution Theorem.	
2-4	**Applications of Fourier Transforms**: Boundary Value Problems, Heat Conduction in Solids, Mechanical Vibrations, Potential Theory.	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Text-Books			
PHY503-T01	Mathematical Methods in Physics	2022	Publication 2497 YCMOU, Nashik
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
PHY503: RB1	Ordinary Differential Equations – Dr. H.L. Tidke, Dr. L. N. Katkar for CR 01	2021	978-93-91514-52-5
PHY503: RB2	Integral Transforms - Dr. S. D. Katore, Dr. D. D. Pawar for CR 02	2020	978-93-91514-62-4
PHY503: RB3	Linear Algebra – Dr. J. N. Chaudhari, Dr. N. S. Darkunde	2021	978-93-91514-60-0
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
PHY501 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
PHY501-WL1			

COURSE OUTCOMES

After successful completion of this course, student should be able to

- Understand the basic concepts of mathematics required to solve complex problems in physics
- Explain linear ODEs with constant coefficients
- Apply the concept of Fourier transform in Physics

PHY504: PHYSICS I– PRACTICAL

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics){2023 Pattern} & V141: M.Sc. (Physics){2022 Pattern}

COURSE INFORMATION

Sem	Major	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
01	DSC	PHY504	Physics I - Practical	4	12	120	50	50	100	P

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully completed: • Candidates with B.Sc./ B.Sc.(Physics)/B.Sc.(Electronics)/B.E./B. Tech Degree or Equivalent pass	This course enables the students to: • Acquire a comprehensive understanding of electronic devices and circuits • Implement and troubleshoot linear and digital electronics circuits. • Design and analyze simple rectifiers and voltage regulators using diodes. • Describe the features and working of various ICs • Create an electronic circuit with a particular function

LAB ACTIVITY

SN	Title of Activity [Finalize the list of activities]	CR
1	To design, build and test Astable / Monostable multivibrator using IC 741/IC 555.	CR01
2	To design a Frequency Modulator Circuit based on IC 741/IC 555.	
3	To Design, build & test square, triangular and sine wave generator using IC 741/IC 555.	
4	To Study of Linear voltage control oscillator using IC 566.	
5	To design a Frequency Modulator Circuit based on IC 566.	
6	To Design of a Voltage-to-Frequency Converter using VCO IC 566	CR02
7	To Design of a Phase Modulator and Demodulator using PLL IC 565	
8	To design and setup a Frequency Multiplier circuit using PLL IC 565 to multiply the input frequency	
9	To Build and test SMPS power supply.	
10	To simplify the given SOP expression and to realize it using Basic gates and Universal gates	
11	To Design, built and test oscillator – Wien Bridge oscillator / phase shift oscillator using OP-AMP.	CR03
12	To Design, build and test Voltage to Frequency / Frequency to voltage converter using OP-AMP	
13	To Build and test Function generator using IC 8038	

14	To Design, build and test the DC to DC converter circuit	
15	To design and Implementation of Current Limiting Protection Circuitry using IC 78XX/IC 79XX.	
16	To Design and Implementation of Low Dropout (LDO) Voltage Regulators using IC 78XX/IC 79XX.	**CR04**
17	To Design and Implementation of a Voltage Measurement Circuit using ICL 7106	
18	To Design and Construction of a Temperature Measurement Circuit using ICL 7106	
19	To Design and Implementation of a Simple Decade Counter Circuit using IC 7490.	
20	To Design and Analysis of Binary to BCD Conversion Circuit using IC 7490.	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Course Website Link for (1) Mobile and Online Lectures, (2) Discussion Forum for online interaction and (3)Self-Test for each CR Block, Continuous Assessment Test and End Examination			
Text-Books			
PHY504–P01	Electronic Devices -Ms. Sweta Kapade, Mr. Manish Shingare	2022	Publication 2571 YCMOU, Nashik
PHY504-T01	Electronic Devices - Dr. Chetana Kamlaskar	2022	978-9395855068 YCMOU, Nashik
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
PHY504:RB1	Operational Amplifiers – G. B. Clayton	5th edition	
PHY504:RB2	OPAMPS and Linear Integrated Circuits - Ramakant Gayakwad,		Prentice Hall
PHY504:RB3	Linear Integrated Circuits – D. Roy Choudhary, Shail Jain		
PHY504:RB4	Electronic Principles – A. P. Malvino, TMH		
PHY504:RB5	Power Supplies – B. S. Sonde		
PHY504:RB6	SMPS, Inverters, Converters – Gottlieb		
PHY504:RB7	Digital Principles and Applications - Leach and Malvino		
PHY504:RB8	Digital Electronics - R. P. Jain		
PHY504:RB9	Data Converters - B. S. Sonde		
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
PHY504:CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
PHY504:WL1	MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/		

PHY504:WL2	National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd		
PHY504:WL3	Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8		
PHY504:WL4	https://vlab.amrita.edu/		
PHY504:WL5	https://www.vlab.co.in/		
PHY504:WL6	http://vlabs.iitb.ac.in/vlab/labsps.html		
OER: Explore additional details and reinforce learning, with this optional learning resource!			
PHY504:OER1	College Physics @ https://goo.gl/89ehG7		1-947172-01-8 OpenStax
PHY504:OER2	University Physics 01 @ https://goo.gl/mWKsdh		1-947172-20-4 OpenStax
PHY504:OER3	University Physics 02 @ https://goo.gl/1xnA6H		1-947172-21-2 OpenStax
PHY504:OER4	University Physics 03 @ https://goo.gl/43tgzM		1-947172-22-0 OpenStax
PHY504:OER5	PhET Simulations @ https://goo.gl/spSWTM	2017	PhET

Course Outcomes

After successful completion of this course, student should be able to

- Explain a concept used in electronic devices and circuits
- Gain a hands on experience working with real time circuits, to translate theory into practice
- Design, Test and verify the operation of simple circuits

RES 505: RESEARCH METHODOLOGY

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V141: M.Sc.(Physics) {2022 Pattern}, V151: M.Sc.(Mathematics){2023 Pattern}, V152: M.Sc.(Environmental Science){2023 Pattern}, V153: M.Sc.(Physics) {2023 Pattern}, V154: M.Sc.(Chemistry) {2023 Pattern}, V155: M.Sc.(Zoology) {2023 Pattern}, V156: M.Sc.(Botany) {2023 Pattern}

COURSE INFORMATION

Sem	Other	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
01	RM	RES505	Research Methodology	4	12	120	30	70	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully completed: • Candidates with B.Sc./ B.Sc.(Agri)/B.E./B.Tech./B. Pharm. Degree or Equivalent pass	The objectives of this course are– • To familiare with various research designs methodology and their appropriate applications. • To study data collection & representation methods • To demonstrate statistical tools for data analysis • To discuss Literature collection, Intellectual Property Rights, Research Databases and Metrics

Units

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	Research Methods in research Experimental design Sampling method	CR 01	As per evaluation pattern, on Each Credit, Student is required to answer • Very Short Answer Question (VSAQ), of 03 marks • Short Answer Question (SAQ), of 05 marks • Long Answer Question (LAQ) of 10 Marks (LAQ may contain sub-questions (a), (b) and so on.)
02-01 02-02 02-03 02-04	Data collections Representation of data Graphical representation Analysis of data	CR 02	
03-01 03-02 03-03 03-04	Use of inferential statistical tools in research Biostatical Test Use of ANOVA Application of correlation of data	CR 03	
04-01 04-02 04-03 04-04	Literature collection Intellectual Property Rights Research Databases Research Metrics	CR 04	

Important Note: This course is common across all Postgraduate Programmes in the 'School of Sciences', the content within the Research Methodology course should incorporate illustrations and examples relevant to their respective domains or disciplines.

Detailed Syllabus

UN	Detailed Syllabus of the Unit	CR
1-1	**Research**:basic and applied research, essential steps in research, Research – definition, importance and application.	CR 01
1-2	**Methods in research**: General methods in research–natural observation, field study, and experimentations.	
1-3	**Experimental design**–basic principles, hypothesis, one & two group experimental design. Matched pair data analysis, factorial design, randomized block design.	
1-4	**Sampling method**-Concept of population, random sampling and non random sampling, variables –random, independent and intervening variables.	
2-1	**Data collections**: methods for primary data-observation, interview, questionnaire methods, and experiments, Methods for secondary data–scientific journals, books, reports, databases.	CR 02
2-2	**Representation of data**: Tabular representations of quantitative data, frequency table– one way and two way.	
2-3	**Graphical representation**: Graphical representation of quanlitative data–line graph, histogram, frequency polygon, frequency curve, Ogive, bar diagrams and pie diagrams.	
2-4	**Analysis of data**–Tools of statistics and software applications.	
3-1	**Use of inferential statistical tools in research**: Use of different statistical estimations depending on the type of data, hypothesis testing, and test of significance.	CR 03
3-2	**Biostatical Test**: Student's 't'test–applications and importance in research data And Application of Chi-square test for the experimental data	
3-3	**Use of ANOVA**: (one-way and two-way ANOVA) for the research data analysis.	
3-4	**Application of correlation of data**: Application of correlation and regression analysis for the data.	
4-1	**Literature collection**: Need, review process, consulting source material, literature citation; Components of research report– Text, tables, figures, bibliography, Writing of dissertations, project proposals, project reports, research papers.	CR 04
4-2	**Intellectual Property Rights**: Basics of patent, Types of Patents (patents, copyrights, trademarks, Geographical Indications, Industrial Designs, and traditional knowledge, Patent application process (Searching a patent, Drafting a patent, Filing of patent, Types of patent applications), Patent documents (Specifications and Claims).	
4-3	**Research Databases:** Types of Databases - Indexing Databases and benefits of Indexing, Citation Index Database; Major Citation Indexing Services - Web of Science /Web of Knowledge (WoS/WoK), Scopus/Science Direct, Google Scholar, CiteSeerX, World Wide Science (WWS), IEEE Xplore, PubMed Central	

	(PMC) Database, Directory of Open Access Journals (DOAJ), Indian Citation Index (ICI) Database, E-Theses Online Service (EThOS), Preprint site arXiv. [Refer Chapter 13 of Academic Integrity and Research Quality]	
4-4	**Research Metrics:** Journal Metrics- Impact Factor (IF) or Journal Impact Factor(JIF), List of Impact Factor of Various Journals, Problems of the Impact Factor and the Editorial Ethics, Cite Score, Difference between Cite Score and Impact Factor, Impact Per Publication (IPP); Newly Emerged Indicators - Source Normalised Impact Per Paper (SNIP), Scimago Journal Rank (SJR), Eigenfactor, Article Influence, SCImago Journal; Author level Metrics- H-Index with its Advantages and limitations, G-Index, i10/20 Index; Altmetrics with its Advantages and limitations; Unique ID for Research Contributors/Author. [Refer Chapter 13 and 14 of Academic Integrity and Research Quality]	

Learning resource details

LR Code	Title Author	Edition Year	ISBN Publisher
Course Website Link for (1) Mobile and Online Lectures, (2) Discussion Forum for online interaction and (3)Self-Test for each CR Block, Continuous Assessment Test and End Examination			
Text-Books			
RES505-T01	Research Methodology (Unit 01 to 14 only), Available here	2022	978-9395855624 YCMOU, Nashik
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
RES505:RB1	Research Methods in Environmental Studies: A Social Science Approach, – Ismael Vaccaro, Eric Alden Smith, and Shankar Aswani	1st Edition, 2010	978-0813344113 Routledge
RES505:RB2	Environmental Social Science: Human-Environment Interactions and Sustainability, – Emilio F. Moran, Edward A. Rosa, and Anantha K. Duraiappah	1st Edition, 2010	978-1402090346 Springer
RES505:RB3	Handbook of Research Methods and Applications in Environmental Studies, – Matthias Ruth and Brynhildur Davidsdottir	1st Edition, 2018	978-1785364327 Edward Elgar Publishing
RES505:RB4	Research Methods for Environmental Studies: A Social Science Approach, – Mark L. Nichter and Mimi Nichter	1st Edition, 1991	978-0306438297 Springer
RES505- RB5	Academic Integrity and Research Quality (Chapter 13 and 14)	Dec 2021	e-Books , UGC web site
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
RES505:CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
RES505-	Academic Integrity and Research Quality	Dec	UGC

WL1		2021	
RES505-WL2	Guidance Document: Good Academic Research Practices	Sept 2020	UGC
OER: Explore additional details and reinforce learning, with this optional learning resource!			
RES505-OER1			

COURSE OUTCOMES

After successful completion of this course, student should be able to –

- Understand some basic concepts of research and its methodologies.
- Select proper method of Data collection & representation
- Select and apply appropriate statistical method for data analysis.
- Perform literature review, research writings with the knowledge of Intellectual Property Rights.
- Identify and address ethical considerations in research, ensuring the protection of participants and data integrity.

PHY506: EXPERIMENTAL TECHNIQUES IN PHYSICS

PROGRAMME INFORMATION

SN	Description	Details
1	University	YashwantraoChavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics){2023 Pattern} & V141: M.Sc. (Physics){2022 Pattern}

COURSE INFORMATION

Sem	Major	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
01	DSE	PHY506	Experimental Techniques in Physics	4	12	120	30	70	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully completed: • Candidates with B.Sc./ B.Sc.(Physics)/B.Sc.(Electronics)/B.E ./B. Tech Degree or Equivalent pass	This course enables the students: • Understand the materials characterization techniques and the instrumentation aspects • Introduce the fundamental understanding of characterization techniques which are commonly used for material analysis • Develop and imparts the systematic steps for interpretation of data obtained from the characterization

UNITS

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	Vacuum Physics Gas transport properties Vacuum Technology and Surface PhysicsVacuumSystem-I Vacuum Technology and Surface PhysicsVacuum System- II	CR 01	As per evaluation pattern, on Each Credit, Student is required to answer • Very Short Answer Question (VSAQ), of 03 marks • Short Answer Question (SAQ), of 05 marks • Long Answer Question (LAQ) of 10 Marks (LAQ may contain sub-questions (a), (b) and so on.)
02-01 02-02 02-03 02-04	Pumps for High Vacuum (HV) and Ultra High Vacuum (UHV): Vacuum Gauges Low temperatures techniques low temperature production techniques	CR 02	
03-01 03-02 03-03 03-04	Structural Characterization and Thermal Analysis Techniques used for XRD CharacterizationTechniques-I CharacterizationTechniques-II	CR 03	
04-01 04-02 04-03 04-04	Morphological and Magnetic Characterization Electron Microscopy- Principle, Instrumentation and Working Probe Microscopy- Principle, Instrumentation and Working Magnetic Characterization- Principle, Instrumentation and Working	CR 04	

DETAILED SYLLABUS

UN	Detailed Syllabus of the Unit	CR
1-1	**Vacuum Physics:** Important and fields applications of vacuum, kinetic theory of gases, impingement rate of molecules on a surface, average velocity of gas and mean free path.	CR 01
1-2	**Gas transport properties**: Thermal conductivity, viscosity and diffusion	
1-3	**Vacuum Technology and Surface PhysicsVacuumSystem-I:**Various ranges of vacuum, gas conductance of a vacuum line, gas impedance of a vacuum line, pumping speed, flow of gases through apertures, elbows, tubes etc. for viscous and molecular flow regimes, pump down time	
1-4	**Vacuum Technology and Surface PhysicsVacuum System- II:**Gas Flow: Nature of Gas Flow, Turbulent Flow, Viscous, Streamline, or Laminar Flow, Molecular Flow, Flow Relationships Conductance: Conductance, Conductances in Parallel, Conductances in Series, Flow Calculations, Equations for Viscous Flow, Equations for Molecular Flow	
2-1	**Pumps for High Vacuum (HV) and Ultra High Vacuum (UHV):** Principles of pumping concept, Types of vacuum pumps: Rotary, Molecular drag, Diffusion, Cryogenic, Getter, Titanium sublimation, Sputter ion, Orbitron.	CR 02
2-2	**Vacuum Gauges:**McLeod, Thermocouple (Pirani), Penning, Hot cathode ionization (triode type), Bayard-Alpert Leak detection, Vacuum system design.	
2-3	**Low temperatures techniques**: Refrigeration principle -including thermodynamical aspects	
2-4	**low temperature production techniques**:Throttling process	
3-1	**Structural Characterization and Thermal Analysis :** X-ray Diffraction - Bragg's diffraction condition, principle, instrumentation (with filters) and working	CR 03
3-2	**Techniques used for XRD:** Laue's method, Rotating crystal method, Powder (Debye- Scherrer) method, Derivation of Scherrerformula for size determination.	
3-3	**CharacterizationTechniques-I** : principle, instrumentation and working: Infra- Red (IR), Fourier Transform Infra-Red (FTIR)	
3-4	**CharacterizationTechniques-II** : Ultraviolet-Visible (UV-VIS), Diffused Reflectance Spectroscopy (DRS), X-ray Absorption (XPS),	
4-1	**Morphological and Magnetic Characterization:** Optical Microscopy: Principle, Instrumentation and Working of optical microscope	CR 04
4-2	**Electron Microscopy- Principle, Instrumentation and Working :** Scanning ElectronMicroscope (SEM), Field Emission Scanning Electron Microscope (FESEM) –Advantages over SEM, Transmission Electron Microscope (TEM), Selected AreaElectron Diffraction (SAED)	
4-3	**Probe Microscopy- Principle, Instrumentation and Working :** Scanning Tunneling Microscope (STM) and Atomic Force Microscope (AFM)	
4-4	**Magnetic Characterization- Principle, Instrumentation and Working:**Vibrating Sample Magnetometer (VSM), Analysis of Hysteresis loop, SQUID Technique: Principle, Instrumentation and Working. Numerical	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Text-Books			
PHY506-T01	Experimental Techniques	2022	978-9392982651

	- Dr. S.R. Gadakh		YCMOU, Nashik
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
PHY506:RB1	Vacuum Physics and Techniques –T. A. Delchar, Chapman and Hall		
PHY506:RB2	Vacuum Technology –A. Roth	1990	North Holland, Elsevier Science B.V.
PHY506:RB3	High vacuum techniques –J. Yarwood	1967	Chapman and Hall, London
PHY506:RB4	Experimental principles and methods below 1 –K, O. U. Lounasmaa	1974	Academic Press, London and, New York
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
PHY506-CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
PHY506-WL1			

Course Outcomes

After successful completion of this course, student should be able to

- Understand the important concepts and methods in experimental techniques
- Explain the working principles of the various techniques in experimental Physics
- Analyze the most commonly employed Characterization techniques used in Physics

PHY507: PHYSICS OF LASERs

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics){2023 Pattern} & V141: M.Sc. (Physics){2022 Pattern}

COURSE INFORMATION

Sem	Major	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
02	DSE	PHY507	Physics of LASERs	4	12	120	30	70	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • Candidates with B.Sc. / B.Sc.(Physics)/B.Sc.(Electronics)/B.E./B. Tech Degree or Equivalent pass	This course enables the students: • Understand basic concepts, principles, and theoretical treatments of LASERs • Calculate key parameters of LASERs • Analyse LASER rate equations and to derive conditions for stable action • Explain LASER Characteristics • Study types of LASERs with their applications

UNITS

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	General Introduction Emission Line Broadening Mechanisms Laser Rate Equations	CR 01	As per evaluation pattern, on Each Credit, Student is required to answer • Very Short Answer Question (VSAQ), of 03 marks • Short Answer Question (SAQ), of 05 marks • Long Answer Question (LAQ) of 10 Marks (LAQ may contain sub-questions (a), (b) and so on.)
02-01 02-02 02-03 02-04	Laser Amplifiers Resonance Frequency Resonators Spherical Mirror Resonators	CR 02	
03-01 03-02 03-03 03-04	Mirror Resonator The Threshold Condition Characteristics LASER Properties	CR 03	
04-01 04-02 04-03 04-04	LASER Characteristics Types of LASER LASER Amplifiers LASER Safety	CR 04	

DETAILED SYLLABUS

UN	Detailed Syllabus of the Unit [To be update as per SLM]	CR
1-1	**General Introduction:** Scope and Contents, Interaction of Radiation with Matter, The Einstein Coefficients, Atomic Lineshape Function, g(Î½),	CR 01
1-2	**Emission:**Amplification by Stimulated Emission	
1-3	**Line Broadening Mechanisms:** Line Broadening Mechanisms-1,Line Broadening Mechanisms- 2	
1-4	**Laser Rate Equations:** Laser Rate Equations: 2-Level System, Laser Rate Equations: 3-Level System, Laser Rate Equations: 4-Level System	
2-1	**Laser Amplifiers:** Er-Doped Fiber Amplifier	CR 02
2-2	**Resonance Frequency:** Resonance Frequencies, Spectral Response of an Optical Resonator, Resonator Loss and Cavity Lifetime	
2-3	**Resonators:** Spherical Mirror Resonators, Resonator Stability Condition	
2-4	**Spherical Mirror Resonators :**Ray Paths in Spherical Mirror Resonators	
3-1	**Mirror Resonator:**Tranverse Modes of a Spherical Mirror Resonator, Gaussian Mode of the Spherical Mirror Resonator, Longitudinal Modes of a Spherical Mirror Resonator	CR 03
3-2	**The Threshold Condition:**Laser Oscillations & The Threshold Condition, Spectral Hole Burning, Variation of Laser Power around Threshold, Optimum Output Coupling	
3-3	**Characteristics**: Laser Output Characteristics	
3-4	**LASER Properties:**Laser Beam , Ultimate Linewidth of a Laser	
4-1	**LASER Characteristics:** Pulsed Lasers, Q-Switching, Mode Locking, Methods of Mode Locking	CR 04
4-2	**Types of LASER :** Some Common Lasers, Fiber Lasers, Semiconductor Lasers	
4-3	**LASER Amplifiers:** Lasers and Laser Amplifiers in Optical Fiber Communication, Lasers in Nonlinear Optics	
4-4	**LASER Safety:** Laser Safety	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Text-Books			
	-		
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
PHY507 – RB1			
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
PHY507 - CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
PHY610-WL1	**Link for this course:** https://nptel.ac.in/courses/115/102/115102124/		

Course Outcomes

After successful completion of this course, student should be able to

- Describe the concept of stimulated emission and what is an active medium
- Describe the different types of lasers, its principle, properties of laser beam and significance of the Lasers materials
- Understand Laser Physics, and Laser devices to analyze and quantify complex problems in the field of nanotechnology

SEMESTER 02

PHY509: ATOMIC AND MOLECULAR PHYSICS

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics){2023 Pattern} & V141: M.Sc. (Physics){2022 Pattern}

COURSE INFORMATION

Sem	Major	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
02	DSC	PHY509	Atomic and Molecular Physics	4	12	120	30	70	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully completed: • Candidates with B.Sc./ B.Sc.(Physics)/B.Sc.(Electronics)/B.E./B. Tech Degree or Equivalent pass	This course enables the students: • Learn about the intricacies of spectra of Hydrogen-like atoms • Understand the details of rotational, vibrational and Raman spectra of molecules. • Know about the different regions of spectra, and the corresponding instrumentations. • Learn about NMR spectra and its application • Understand the principles of mass spectroscopy and ionization methods

UNITS

UN	Name of the Unit {Updated as per SLM book on 22 Feb 2024}	CSs	Questions
01-01 01-02 01-03 01-04	Atomic structure and atomic spectra Electronic Configuration One and Two Electron Spectra Atom in Magnetic Field	CR 01	As per evaluation pattern, on Each Credit, Student is required to answer • Very Short Answer Question (VSAQ), of 03 marks • Short Answer Question (SAQ), of 05 marks • Long Answer
02-01 02-02 02-03 02-04	Molecules Vibrational Coarse Structure Frank – Condon principle Rotational Fine Structure	CR 02	
03-01 03-02 03-03 03-04	Electron Spin Resonance (ESR) Total Hamiltonian Nuclear Magnetic Resonance (NMR) Relaxation Process	CR 03	

04-01 04-02 04-03 04-04	X-ray Diffraction Lattice Vibrations Vibrational modes of Diatomic Lattice Lattice Heat Capacity	**CR 04**	Question (LAQ) of 10 Marks (LAQ may contain sub-questions (a), (b) and so on.)

DETAILED SYLLABUS

UN	Detailed Syllabus of the Unit	CR
1-1	**Atomic structure and atomic spectra** :- Revision of quantum numbers	**CR 01**
1-2	**Electronic Configuration:** electron configuration, Hund's rule, origin of spectral lines, selection rules	
1-3	**One and Two Electron Spectra:** two electron spectra, fine structure and hyperfine structure	
1-4	**Atom in Magnetic Field**: Normal and Anomalous , Paschen- Back effect	
2-1	**Molecules** : Rotational and vibrational spectra for diatomic molecules	**CR 02**
2-2	**Vibrational Coarse Structure** : Electronics spectra of diatomic molecules, vibration course structure, vibrational analysis of band system	
2-3	**Frank – Condon principle**: Dissociation energy and dissociation products	
2-4	**Rotational Fine Structure:** Rotational fine structure of electronic vibration transitions, electronic angular momentum in diatomic molecules.	
3-1	**Electron Spin Resonance (ESR):** Principles of ESR, ESR spectrometer	**CR 03**
3-2	**Total Hamiltonian**: Total Hamiltonian, hyperfine structure.	
3-3	**Nuclear Magnetic Resonance (NMR):** Magnetic properties of nucleus, resonance condition, NMR instrumentation	
3-4	**Relaxation Process:**Relaxation process, chemical shift.	
4-1	**X-ray diffraction**: Geometrical structure factor, Atomic scattering factor, calculations for sc, bcc, fcc, hcp& diamond structure	**CR 04**
4-2	**Lattice Vibrations:** Phonon, Vibrational modes of monoatomic linear lattice & diatomic lattice	
4-3	**Vibrational modes of Diatomic Lattice**: Acoustic & optical modes of vibration.	
4-4	**Lattice heat capacity**: Einstein & Debye model of lattice heat capacity; Normal & Umklapp processes.	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Text-Books			
PHY509-T01	Atomic & Molecular Physics - Dr. Amol B. Rahane	2023	978-9395855952 YCMOU, Nashik
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
PHY509: RB1	Fundamentals of Molecular spectroscopy -Collin N. Banwell and Elaine M.		McCASH
PHY509: RB2	Molecular structure and Spectroscopy -G. Aruldhas.		
PHY509: RB3	Quantum Physics		

	– Robert Eiesberg and Robert Resnik		
PHY509: RB4	Introduction to solid states Physics - Charles, Kittle		7th Edition
PHY509: RB5	Solid States Physics – A.J. Dekkar		
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
PHY509 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
PHY509-WL1			

Course Outcomes

After successful completion of this course, student should be able to

- Explain the change in behavior of atoms in external applied electric and magnetic field
- Correlate rotational, vibrational, electronic and rotation-vibration spectra of molecules
- Understand the interaction of atoms in strong and weak magnetic field
- Characterized a broad knowledge of the most important concept of atoms and molecules
- Understand different spectroscopic techniques and their significance

PHY510: ELECTRODYNAMICS

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics){2023 Pattern} & V141: M.Sc. (Physics){2022 Pattern}

COURSE INFORMATION

Sem	Major	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
02	DSC	PHY510	Electrodynamics	4	12	120	30	70	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully completed: • Candidates with B.Sc./ B.Sc.(Physics)/B.Sc.(Electronics)/B .E./ B. Tech Degree or Equivalent pass	This course enables the students: • Study the basic concepts regarding Maxwell's equations • Impart knowledge about Relativistic Mechanics and Covariance • Understand the basics of electrostatics, magneto statics, electrodynamics and the potential formulation of basic laws. • Understand how to apply basic theories in electromagnetic waves and radiation. • Render insights into fields generated by oscillating sources, and their applications.

UNITS

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	Multipole expansions linear quadrapole potential and field Faraday's law Maxwell's equations	CR 01	As per evaluation pattern, on Each Credit, Student is required to answer • Very Short Answer Question (VSAQ), of 03 marks • Short Answer Question (SAQ), of 05 marks • Long Answer Question (LAQ) of 10 Marks
02-01 02-02 02-03 02-04	Energy relations in quasi-stationary current systems Poynting's theorem Electromagnetic wave equations Electromagnetic waves	CR 02	
03-01 03-02 03-03 03-04	Inhomogeneous wave equations Gauge transformations Wave equations Hertz potential	CR 03	

04-01 04-02 04-03 04-04	Special theory of relativity Lorentz transformations Minkowski's space-time diagram Four vector potential	**CR 04**	(LAQ may contain sub-questions (a), (b) and so on.)

DETAILED SYLLABUS

UN	Detailed Syllabus of the Unit	CR
1-1	**Multipole expansions**: Multipole expansions for a localized charge distribution in free space	**CR 01**
1-2	**linear quadrapole potential and field:** static electric and magnetic fields in material media, boundary conditions, Time dependent fields,	
1-3	**Faraday's law**:Faraday's law for stationary media, Faraday's law for moving media	
1-4	**Maxwell's equations**: Maxwell's displacement current, differential and integral forms of Maxwell's equations, Maxwell's equations for moving medium.	
2-1	**Energy relations in quasi-stationary current systems**: Magnetic interaction between two current loops, Energy stored in electric and magnetic fields,	**CR 02**
2-2	**Poynting's theorem**: General expression for electromagnetic energy	
2-3	**Electromagnetic wave equations**: Electromagnetic plane waves in stationary medium, Reflection and refraction of electromagnetic waves at plane boundaries (Oblique incidence)	
2-4	**Electromagnetic waves**: Electromagnetic waves in conducting medium, Skin effect and skin depth.	
3-1	**Inhomogeneous wave equations:** The wave equation for E and B	**CR 03**
3-2	**Gauge transformations**: Lorentz's and Coulomb's gauges	
3-3	**Wave equations**: Wave equations in terms of electromagnetic potentials, D'Alembertian operator	
3-4	**Hertz potential**: Hertz potential and its use in computation of radiation fields.	
4-1	**Special theory of relativity**: Experimental basis for special theory of relativity (Michelson – Morley experiment)	**CR 04**
4-2	**Lorentz transformations**: Relativistic velocity addition	
4-3	**Minkowski'sspace-time diagram:** length contradiction, time dilation	
4-4	**Four vector potential**: Electromagnetic field tensor, Lorentz force on a charged particle.	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Text-Books			
PHY510-T01	Electrodynamics - Dr Rajendra Vadnere	2022	978-9392982668 YCMOU, Nashik
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
PHY510: RB1	Classical Electrodynamics -J.D. Jackson	4Th edition 2005	John Wiley & sons
PHY510:	Classical Electricity and Magnetism,	2nd	Addison- Wesley

RB2	-W.K.H. Panofsky and M. Phillips	edition 1962	
PHY510: RB3	Introduction to Electrodynamics -D.J. Griffiths	2nd Ed 1989	Prentice Hall, India.
PHY510: RB4	Foundation of Electromagnetic Theory -J.R. Reitz ,E.J. Milford and R.W. Christy,	4th ed., 1993	Addison -Wesley
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
PHY510-CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
PHY510-WL1			

Course Outcomes

After successful completion of this course, student should be able to

- Understand the concepts of electrodynamics and Maxwell equations and their applications in various situations
- Understand concepts in electric field and scalar potential, magnetic field and vector potential
- Identify electromagnetic potentials, gauge transformations and Lorentz transformations.
- Inhomogeneous wave equations and their significance
- Understanding the electrodynamics to create a scientific temperament

PHY511: QUANTUM MECHANICS- I

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics){2023 Pattern} & V141: M.Sc. (Physics){2022 Pattern}

COURSE INFORMATION

Sem	Major	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
02	DSC	PHY511	Quantum Mechanics - I	2	06	60	15	35	50	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully completed: • Candidates with B.Sc./ B.Sc.(Physics)/B.Sc.(Electronics)/ B.E./B. Tech Degree or Equivalent pass	This course enables the students: • Understand the fundamentals of quantum mechanics • Make familiar with various quantum mechanical problems related to vector space, eigenvalue, Schrödinger equation, free particle, harmonic oscillator, potential barrier and well, angular momenta etc. • Aware the students about applications of quantum mechanics in various science branches • Importance of relativistic quantum mechanics compared to nonrelativistic quantum mechanics. • Exposure to quantum field theory and universal interactions.

Note: This is OER. Link for this course: https://nptel.ac.in/courses/115/101/115101107/, https://nptel.ac.in/courses/115/103/115103104/

UNITS

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	Introduction to Quantum Mechanics BoundStates Linear Vector Space (LVS) Function Spaces	CR 01	As per evaluation pattern, on Each Credit, Student is required to answer • Very Short Answer Question (VSAQ), of 03 marks • Short Answer Question (SAQ), of 05 marks • Long Answer Question (LAQ) of 10 Marks (LAQ may contain sub-questions (a), (b) and so on.)
02-01 02-02 02-03 02-04	Classical vs Quantum Mechanics Schrodinger and Heisenberg Pictures Hydrogen Atom & Wave Functions Harmonic Oscillator	CR 02	

DETAILED SYLLABUS

UN	Detailed Syllabus of the Unit	CR
1-1	**Introduction to Quantum Mechanics:** Review of Particle in Box, Potential Well, Barrier, Harmonic Oscillator	CR 01
1-2	**BoundStates:** Bound States, Conditions and Solutions for one Dimensional Bound States – I, Conditions and Solutions for one Dimensional Bound States – II	
1-3	**Linear Vector Space (LVS):** Linear Vector Space (LVS), Basis for Operators and States in LVS – I	
1-4	**Function Spaces** : Function Spaces, Postulates of Quantum Mechanics – I	
2-1	**Classical vs Quantum Mechanics :**Compatible vs Incompatible Observable – I	CR 02
2-2	**Schrodinger and Heisenberg Pictures**: Schrodinger and Heisenberg Pictures, Solutions to other Coupled Potential Energies	
2-3	**Hydrogen Atom & Wave Functions:** Wave Functions, Angular Momentum Operators, Identical Particles,Hydrogen Atom & Wave Functions & Quantum Computer – I, Identical Particles & Quantum Computer – II	
2-4	**Harmonic Oscillator:** Harmonic Oscillator, Ladder Operators	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Text-Books			
PHY511-T01	Quantum Mechanics –Mr. Manish Shingare	2022	YCMOU, Nashik
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
PHY511: RB1	A Text-book of Quantum Mechanics, P.M.Mathews and K.Venkatesan		
PHY511: RB1	Quantum mechanics, A. Ghatak and S. Lokanathan		
PHY511: RB1	Modern Quantum mechanics, J. J.Sakurai		
PHY511: RB1	Introduction to Quantum Mechanics, David J.Griffiths		
PHY511: RB1	Quntum Mechanics, NouredineZettili		A John Wiley and Sons, Ltd., Publication
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
PHY511 - CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
PHY511-WL1	**https://nptel.ac.in/courses/115/101/115101107/, https://nptel.ac.in/courses/115/103/115103104/**		

Course Outcomes

After successful completion of this course, student should be able to

- Explore the basic concepts of quantum Mechanics
- Solve special functions and matrices for solving Quantum Mechanical Problems
- Understand various quantum mechanical features by solving various potentials: example, Finite and infinite well, Harmonic oscillator
- Apply the time – dependent and time – independent Schrödinger's equations
- Apply the knowledge of Variational Methods for particle in box, Harmonic oscillator and Delta Function along with WKB approximation for classical Region and Tunneling

PHY512: Physics II – Practical

(Computational Methods using 'C' program)

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics){2023 Pattern} & V141: M.Sc. (Physics){2022 Pattern}

COURSE INFORMATION

Sem	Major	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
02	DSC	PHY512	Physics II - Practical	4	12	120	50	50	100	P

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully completed: • Candidates with B.Sc./ B.Sc.(Physics)/B.Sc.(Electronics)/B.E. /B. Tech Degree or Equivalent pass	This course enables the students: • To comprehend the programming basics and the fundamentals of C programming language • To write programs for computational methods using C language • Impart basic knowledge of computational physics in solving the physics problems. • Understand the mathematical and logical operations

Note: (1) The theoretical background relevant to the experiments listed below should be discussed during practical sessions only.

(2) Wherever possible, the output should be presented in graphical form also.

LAB ACTIVITY

Sn.	Title of Activity	CR
1	Sum of digits of an integer	CR 01
2	To find factorial of a number	
3	Checking and printing of prime numbers	
4	To find sin(x), cos(x) using series method	
5	Sorting of (1) Numerical data (2) Character type data- ascending, descending.	CR 02
6	Use of pointers – sorting (any one method of sorting)	
7	Matrix operations – addition, subtraction, multiplication	
8	Root of equation-Bisection method, Newton Raphson method	
9	Numerical integration- Trapezoidal, Simpson's 1/3rd rule.	CR 03
10	Roots of an algebraic equation (Bisection)	

11	Roots of polynomial (Newton Raphson)	
12	Legendre polynomials using the standard recurrence relation. Confirm that the method works well for Legendre functions by comparing with standard tables for special functions. (Use forward recursion.)	
13	Bessel functions of the first kind using the standard recurrence relation.	CR 04
14	Interpolation: Interpolate the value of a function at a point. Use Lagrange interpolation method.	
15	Rotation of matrix: Rotate the elements of a n x n matrix in clockwise/ anticlockwise direction and display the matrices (n>=5).	
16	Inverse of a matrix: Find the inverse of anxn matrix and display both matrices.	
17	Trapezoidal/ Simpson rule: Evaluate a given function f(x) using Trapezoidal/ Simpson rule correct up to given accuracy by successively halving the step size.	
18	Graphics: Write a program and display the Miller planes in the cubic lattice. Display the FCC, Bcc, and simple cubic lattice on the computer screen.	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Text-Books			
PHY512–P01	Programming in C - Dr. Amol B. Rahane	2022	Publication 2572 YCMOU, Nashik
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
PHY512 -RB1	The C programming Language –B.W.Kernighan and D.M.Ritchie	1985	Prentice Hall of India Pvt.Ltd
PHY512 -RB1	Schuam's series "programming in C".		
PHY512 -RB1	Introductory Methods of Numaricle Analysis -S.S.Sastry	1990	Prentice Hall of India Pvt.Ltd
PHY512 -RB1	Computational Physics -R.C.Verma, P.K.Ahluwalia and K.C.Sharma	1999	New Age International Publishers
PHY512 -RB1	Computational Physics –S.E.Koonin	1999	Benjamin/Cumming Pub .Co
PHY512 -RB1	Computer Method for Engineering, –Y.JalurIa	1988	Allyn and Bacon Inc
PHY512 -RB1	An Introduction to Computational Physics, –T.Pang	1997	Cambridge Uni. Press
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
PHY512 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
PHY512-WL1	https://spoken-tutorial.org/tutorial-search/?search_foss=C+and+Cpp&search_language=English		

Course Outcomes

After successful completion of this course, student should be able to

- Use numerical methods in solving problems in Physics.
- Develop logics which will help to programme with the C high-level language.
- Analyze data using computational methods.
- Identify modern programming methods and describe the extent and limitations of computational methods in Physics

PHY513: On Job Training

Programme Information

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics){2023 Pattern}

Course Information

Sem	Other	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
02	OJT	PHY513	On Job Training	4	12	120	50	50	100	TW

Presumed Knowledge and Learning Objectives

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • Candidates with B.Sc. / B.Sc.(Physics)/B.Sc.(Electronics)/B.E./B. Tech Degree or Equivalent pass	This course enables the students: • To Provide opportunities to learn, understand and sharpen the required skills at the job with hands-on experiences • Provide an effective training environment to students • Provide opportunities for students to apply theories and principles learned in class to real job settings. • Bridge the gap between academia and the professional world • Promote research and innovation

Details About ON-JOB-TRAINING (OJT)/Internships

Internships offer valuable opportunities for postgraduate students to bridge the gap between academia and the professional world, promote research and innovation. By engaging in hands-on experiences and collaborating with experts, students can develop practical skills, expand their network, and gain insights into potential career paths.

Guidelines: [In process]

A. General:

1) It is mandatory for a student to successfully complete the OJT (Internship) for the award of the PG Diploma / PG Degree. This internship could be the research internshipor any normal industry, Organization/Institute, Start-up/ ATAL Innovation/Incubation centers, Micro/Small/Medium/Enterprise, Govt/NGO/PSU/, Online/offline academic activities at School/Regional Centers/ University Head Quarters, Online Internship related to major courses.

2) In case of working students if his/her job nature is related to major courses or in allied domain then he/she will be permitted for the internship at workplace provided;a declaration by an employer is submitted directly to the LSC head and School. Both, declaration by an employer and the training completion certificate will be attached along with Internship report.

3) Internship is of four credits with a period of 4 weeks and carries a weightage of 50-50% in 'Continuous Assessment (CA)' and 'End examination (EE)'. The internship time period does not extend beyond end examination of OJT.
    - Total Study efforts (including Self-Study) in Hours: Total 120 Hours
    - On-Job-Training/Internship (@during 22working days) in a month: minimum 110Hours
    - Preparation of Internship Report: 10 Hours
    - Duration– i) After end examination of semester 02 and before beginning of semester 03 or ii) Any one month within semester 02 of the programme
4) At the end of the internship, each student is required to provide a printed copy of their consolidated diary/journal and internship report for the evaluation of internship.The report must express exactly what was learned and accomplished during the internship.
5) The Intern will be assessed by
    a) Continuous Assessment (CA) - Mentor of the Industry/ NGO/ organization/ Institute etc where student is selected for Internship
    b) End Examination (EE) - LSC Supervisor/PC and External Examiner.

B. Monitoring and Evaluation:

Monitoring: During internship period as part of 'Continuous assessment (CA)', the mentor should evaluate the interns using the following points and should issue a recommendation letter that whether Intern/student meets the expectations of the internship or not:

1	Behaviors, Shows interest in assigned work, Willingness to learn
2	Accepts responsibility, Cooperates with co-workers and supervisors, Demonstrates organizational skills
3	Uses time, knowledge and expertise effectively, Analyzes problems effectively
4	Demonstrates creativity/ originality / any innovative contribution, Professional ethics and accountability
5	Writes effectively, Produces high quality work/Skill Proficiency

Evaluation: At internship, the intern will be evaluated in the end examination (EE), by aduly constituted expert committee of internal and external, on the following suggestive aspects:

- Professional Attitude
- Maintenance of Daily Diary
- Internship Report
- Viva voce/Oral

Reference-Link: Explore additional details!	
PHY 513 –RL 1	UGC Internship Guidelines https://www.ugc.gov.in/pdfnews/1887287_Rsearch-Internship-Guidelines-120522.pdf
PHY 513 –RL 2	AICTE Internship Portal https://internship.aicte-india.org/
PHY 513 –RL 3	NITI Aayog Internship Scheme https://www.niti.gov.in/internship

Course Outcomes

After successful completion of this course, student should be able to –

- Students will demonstrate proficiency in applying theoretical knowledge and academic concepts to real-world professional situations.
- Students will possess job-specific skills that are relevant to their chosen field of study, enabling them to perform tasks and responsibilities effectively and efficiently.
- Students will acquire a comprehensive understanding of industry practices, trends, and challenges, contributing to their overall knowledge and expertise in the field.
- Students will establish professional networks and relationships, expanding their professional connections and opportunities for future collaborations and career advancement.
- Students will develop problem-solving and critical thinking abilities, demonstrating the ability to analyze complex situations, make informed decisions, and propose effective solutions.
- Students will demonstrate professionalism, adaptability, and effective communication skills in a professional work environment.

PHY514: Field Project

Programme Information

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics){2023 Pattern}

Course Information

Sem	Other	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
02	FP	PHY514	Field Project	4	12	120	50	50	100	TW

Presumed Knowledge and Learning Objectives

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • Candidates with B.Sc. / B.Sc.(Physics)/B.Sc.(Electronics)/B.E./B. Tech Degree or Equivalent pass	This course enables the students: • Apply theoretical knowledge in real-world settings • Develop research and investigative skills • Conduct independent research • Collaborate and communicate effectively • Develop problem-solving and critical thinking abilities

Details About Field Project [In process]

Domains

Maharashtra is a diverse state with various challenges, and research opportunities. Choose a domain that aligns with your interests, the expertise of your faculty, and the resources available in your region. Field projects offer an opportunity to apply theoretical knowledge to real-world situations and contribute to addressing challenges in the region. Some potential domains of field work for Science students are listed as follows. Learner may find this helpful while choosing topic of the field work, but not limited to –

- **Nanotechnology and Nanomaterials**: Investigate the synthesis, characterization, and applications of nanoscale materials in Maharashtra.
- **Solar Cell Efficiency Enhancement**: Study techniques to improve the efficiency of solar cells for better energy conversion in Maharashtra's sunlight conditions.
- **Quantum Computing**: Research quantum computing algorithms and implementations relevant to Maharashtra's computational needs.
- **Medical Imaging Physics**: Explore the physics behind medical imaging techniques like MRI, CT, and ultrasound, with applications in healthcare in Maharashtra.
- **Environmental Monitoring with Remote Sensing**: Use physics-based remote

sensing techniques to monitor and assess environmental changes in Maharashtra.

- **Renewable Energy Technologies**: Investigate the physics of various renewable energy technologies, such as wind turbines and hydroelectric generators.
- **Material Science and Characterization**: Study the physical properties of materials through techniques like X-ray diffraction and electron microscopy, relevant to Maharashtra's industrial needs.
- **Particle Physics Phenomenology**: Explore theoretical models and predictions related to particle physics phenomena, potentially contributing to ongoing research in Maharashtra.
- **Astrophysical Observations**: Conduct observations and data analysis related to astrophysical phenomena using ground-based or space-based telescopes.
- **Biomechanics**: Apply physics principles to study the mechanics of biological systems, such as the movement of organisms or human body functions.
- **Quantum Optics and Information**: Investigate the interaction between light and matter on the quantum level and its applications in quantum information processing.
- **Environmental Physics**: Study the physics of environmental processes like air and water pollution, climate change, and natural resource management.
- **Complex Systems**: Research the behavior of complex systems, such as networks, dynamics, and emergent properties, within Maharashtra's contexts.
- **Advanced Imaging Techniques**: Explore advanced imaging methods like microscopy, spectroscopy, and tomography in the study of diverse materials and systems.
- **Computational Solid State Physics**: Use computational methods to study the electronic and structural properties of solid materials.
- **Quantum Hall Effect and Topological Insulators**: Investigate the quantum behavior of electrons in 2D materials and its applications in electronics.
- **Thin Film Deposition Techniques**: Study techniques for depositing thin films and their applications in electronics, optics, and coatings.
- **Plasma Physics and Fusion Research**: Research the properties and applications of plasma, including its potential use in controlled nuclear fusion.
- **Acoustics and Vibration Analysis**: Explore the physics of sound propagation and vibration phenomena in different materials and systems.
- **High-Energy Astrophysics**: Study the high-energy phenomena in the universe, such as gamma-ray bursts and cosmic rays, using observational data.

Guidelines: [In process]

Topic Selection and Proposal:

Choose a well-defined and feasible topic that aligns with your interests, available resources, and the expertise of your mentors.

Develop a clear and comprehensive project proposal that outlines the research objectives, significance, methodology, and expected outcomes.

Research Planning:

Define your research question and objectives precisely. Identify the scope of your study, study area within Maharashtra, and the timeline for fieldwork.

Conduct a thorough literature review to understand the existing knowledge and identify gaps in the chosen area of study.

Methodology:

Determine the appropriate research methods and techniques based on your research objectives. These might include field surveys, sample collection, laboratory analysis, interviews, or experiments.

Detail the step-by-step procedures you will follow during fieldwork, ensuring they are well-structured and repeatable.

Ethics and Permissions:

If your research involves human subjects, ensure you obtain necessary ethical approvals from your academic institution.

If conducting research/field work in protected areas or involving sensitive species, obtain required permits or approvals from relevant authorities.

Data Collection:

Collect data systematically and accurately according to your defined methodology. Maintain organized records of observations, samples, measurements, and any other relevant information.

Data Analysis:

Organize and manage your collected data in a format suitable for analysis.

Apply appropriate statistical or analytical techniques to interpret your data and draw meaningful conclusions.

Results and Interpretation:

Present your findings using tables, graphs, charts, and descriptive text.

Interpret your results in the context of your research question and compare them with existing literature.

Discussion and Conclusion:

Discuss the implications of your findings, considering how they contribute to the existing knowledge in your field and address the research gaps you identified.

Reflect on any limitations of your study and suggest potential avenues for further research.

Reporting and Documentation:
Create a well-structured report that includes an introduction, objectives, methods, results, discussion, and conclusion sections.
Include proper citations for references to literature.
Visual aids such as photographs, maps, and diagrams can enhance the clarity of your report.

Presentation and Communication:
Present your findings to your academic institution, peers, and mentors through a seminar, presentation, or poster session.
Practice clear and concise communication to effectively convey your research process and outcomes.

Time Management:
Plan your fieldwork, data collection, and analysis schedule to ensure efficient use of time and resources.

Mentorship and Feedback:
Collaborate closely with mentors or advisors who can provide guidance, feedback, and support throughout the project.
Flexibility and Adaptability:
Be prepared to adjust your plans if you encounter unexpected challenges during fieldwork or analysis.

Course Outcomes

After successful completion of this course, student should be able to

- Participate in the projects in industries during his or her industrial training.
- Describe use of advanced tools and techniques encountered during industrial training and visit.
- Interact with industrial personnel and follow engineering practices and discipline prescribed in industry.
- Develop awareness about general workplace behavior and build interpersonal and team skills.
- Prepare professional work reports and presentations.

PHY515: FUNDAMENTALS OF MATERIALS SCIENCE

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics)) {2023 Pattern} & V141: M.Sc. (Physics){2022 Pattern}

COURSE INFORMATION

Sem	Major	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
02	DSE	PHY515	Fundamentals of Materials Science	4	12	120	30	70	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • B.Sc. / B.Sc.(Physics)/ B.Sc.(Electronics)/B.E./ B. Tech Degree or Equivalent pass	This course enables the students: • Engaged in advanced education, research, and development to advance materials science and engineering; or in professional disciplines that benefit from an understanding of MSE. • Employ elements of the materials research process in their careers including the use of critical reasoning to identify fundamental issues and establish directions for investigation • Creative processes to define specific plans for problem solution • analyse thought to interpret results and place them within a broader context • Conduct highest standards of ethical professional practice, understanding the societal and global effects of their work, and using their knowledge and skills to improve the human condition. • Maintain curiosity and expand knowledge and skills through lifelong learning.

UNITS

UN	Name of the Unit {Updated as per SLM book on 22 Feb 2024}	CSs	Questions
01-01 01-02 01-03 01-04	Crystallography Bragg's Law Crystal Defects Line Defects	CR 01	As per evaluation pattern, on Each Credit, Student is required to answer • Very Short Answer Question (VSAQ), of 03 marks
02-01 02-02 02-03 02-04	Motion of dislocations & dislocation density Dislocations and planar defects Phase changes and phase diagrams of single-component materials Thermodynamics of solutions	CR 02	

03-01 03-02 03-03 03-04	Free Energy of Multi-phase Solutions at Equilibrium Binary phase diagrams Spinodals and Binodals True stress and true strain	**CR 03**	• Short Answer Question (SAQ), of 05 marks • Long Answer Question (LAQ) of 10 Marks (LAQ may contain sub-questions (a), (b) and so on.)
04-01 04-02 04-03 04-04	Creep Fracture Structure of Glass, Glass and Glass Ceramics Phase transformations in glass	**CR 04**	

DETAILED SYLLABUS

UN	Detailed Syllabus of the Unit	CR
1-1	**Crystallography**: Growth from Solution, Growth from Water Solution, Low Temperature Solution Growth, Habit of crystals, Solubility, Preliminary Experiment, Apparatus for Crystallization, Slow cooling technique, Solvent Evaporation technique, Temperature-difference Technique, Miller indices of directions, Crystallographic Planes, Directions, Miller indices in hexagonal systems, Weiss Zone Law, Packing in Solids, Closed Packed Structures, Face Centered Cubic (FCC) structure, Hexagonal Closed Packed (HCP), Body Centered Cubic (BCC) Structure, Simple cubic structure, Interstices in the structures, Metallic Crystals, Structure of Common Covalently Bonded Materials ,Structure of common ionic solids	**CR 01**
1-2	**Bragg's Law**: Reciprocal space, Reciprocal lattice, Angles between Bravais lattice planes, Bragg's Law	
1-3	**Crystal Defects**: Classification of Defects, Point Defects, Equilibrium number of Schottky & Frenkel Defects, Equilibrium number of Frenkel Defects	
1-4	**Line Defects**:Deformation, Determination of Shear Strength of Single Crystals (Frenkel Model), Edge Dislocation, Screw Dislocation , Mixed Dislocations	
2-1	**Motion of dislocations & dislocation density**: Slip, Motion of Dislocations & Dislocation Density, Strain Energy of a Dislocation, Stress Field of an Edge Dislocation	**CR 02**
2-2	**Dislocations and planar defects**: Dislocations and Crystal Growth, Planar Defects, Simple grain boundary, Twinning in crystals, Transformation twins, Growth twins, Mechanical twins, Observation of Structural Defects, Surface Methods, Bulk Methods	
2-3	**Phase changes and phase diagrams of single- component materials**: The free energy at phase transitions , Phases of single-component materials, Phase diagrams of single-component materials , The Gibbs Phase Rule, Degrees of freedom (D), Application of the phase rule, Constraints on the shape of phase boundaries (coexistence curves): The Clausius- Clapeyron equation	
2-4	**Thermodynamics of solutions**: Single-component phase diagrams and the Gibbs phase rule, Constraints on the shape of phase boundaries (coexistence curves), Walking along lines of constant temperature or pressure in a single-component phase diagram, Free energy diagrams of ideal solutions, Mixing to form ideal solutions always occurs spontaneously, Extracting chemical potentials from plots of the free energy, Application of solution free energy analysis: Melting point depression, Free energy diagrams of multi-phase solutions , The common tangent construction and the lever rule	
3-1	**Free Energy of Multi-phase Solutions at Equilibrium**: Free energy diagrams of multi-phase solutions, The common tangent construction and the lever rule , How much solid phase forms? How much liquid is present? , Introduction to binary phase diagrams, Binary solutions with limited	**CR 03**

	miscibility: Miscibility gaps , The Regular Solution Model, part I	
3-2	**Binary phase diagrams:**Free energy and phase diagrams of ideal binary solutions, Two-phase equilibrium introduces the phase fraction, determined by the lever rule, Free energy diagrams directly relate to binary phase diagrams, Binary solutions with limited miscibility in the solid state: Miscibility gaps, Eutectic systems , Free energy diagrams of eutectic systems , Analyzing phase equilibria on eutectic phase diagrams , Eutectic Binary Systems,Analyzing phase equilibria on eutectic phase diagrams , Invariant points in binary systems, Other types of invariant points , Congruent phase transitions, Intermediate Compounds in phase diagrams, Example binary phase diagrams , Delineating stable and metastable phase boundaries: spinodals and miscibility gaps, Conditions for stability as a function of composition, Supplementary Information,Ternary solution phase diagrams	
3-3	**Spinodals and Binodals**:Metastable and unstable regions on phase diagrams, Second-order phase transitions , Ferroelectric materials, Statistical Mechanics and Models of Materials , Heat and the microscopic state of materials , A fundamental goal of statistical mechanics , Distinguishable vs. indistinguishable atoms/particles , The first postulate of statistical mechanics tells us the probability of each of these arrangements being found in the ensemble	
3-4	**True stress and true strain**: Stress, Strain, Elastic constants of ceramic polycrystals	
4-1	**Creep**: The Creep Curve, Primary creep, Steady state creep, Mechanisms of steady state creep, Dislocation glide assisted by climb, Creep by diffusion, Creep by grain boundary sliding	
4-2	**Fracture**: Ductile and brittle fracture, Theoretical Fracture Strength, Preexisting cracks in brittle solids, Quantitative treatment of brittle fracture, Treatment of the Griffith crack: The energy balance approach, Stress intensity factor approach, The R curve behavior, Fracture toughness testing, Statistics of brittle fracture	
4-3	**Structure of Glass, Glass and Glass Ceramics**: Introduction of glass, liquid to glass formation a phase transition, The radial distribution functions, Theories of glass formation, Structure of Glass, Structure of oxide glasses, Silica glass, Silicate glasses: glass formers, intermediates and modifiers, Some glass compositions	**CR 04**
4-4	**Phase transformations in glass**: Phase transformations in glass, Liquid-liquid phase separation, Thermodynamic considerations in liquid phase separation, Phase separation by nucleation and growth and by spinodal decomposition, Glass Ceramics	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Text-Books			
	-		
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
PHY515 – RB1	Materials Science and Engineering – William F Smith, JavadHashemi, Ravi Prakash	4th Edition	Tata McGraw Hill,.
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
PHY515 - CD1			

Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
PHY515-WL1	http://nptel.ac.in/courses/113/102/113102080/ http://ocw.mit.edu http://epgp.inflibnet.ac.in		

Course Outcomes

After successful completion of this course, student should be able to

- Explain importance of materials in materials science and engineering field.
- Classify materials according to their types
- Describe basic definition and conception of materials and physical properties of materials

PHY516: Medical Physics

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics){2023 Pattern}

COURSE INFORMATION

Sem	Major	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
02	DSE	PHY516	Medical Physics	4	12	120	30	70	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • Candidates with B.Sc. / B.Sc.(Physics)/ B.Sc. (Electronics)/B.E./B. Tech Degree or Equivalent pass	This course enables the students: • Knowledge of the biological effects of radiation and its application for radiation safety and for radiation treatment. • Knowledge of the operation and principles used in the systems and procedures associated with the clinical track. • Perform the clinical support procedures required of a medical physicist. • Design and complete independent research projects.

UNITS

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	Biomechanics Bioelectricity and Biomagnetism Physics of Hearing Physics of Vision	CR 01	As per evaluation pattern, on Each Credit, Student is required to answer • Very Short Answer Question (VSAQ), of 03 marks • Short Answer Question (SAQ), of 05 marks • Long Answer Question (LAQ) of 10 Marks (LAQ may contain sub-questions (a), (b) and so on.)
02-01 02-02 02-03 02-04	Radiation physics Radiotherapy and Brachytherapy X-ray and Digital Radiography Nuclear Medicine	CR 02	
03-01 03-02 03-03 03-04	Biomaterials New trends in Medical Physics Fundamentals to Biomedical Instrumentation, Patient Safety, Electrodes and Transducer Recording Systems, Cardiovascular System and Measurements	CR 03	

04-01 04-02 04-03 04-04	Heart and Cardiovascular system The Computer in Biomedical Instrumentation and Biomedical Recorders nervous system and neural signals Respiratory system, special care instruments and ultrasonic imaging system	**CR 04**	

DETAILED SYLLABUS

UN	Detailed Syllabus of the Unit	CR
1-1	**Biomechanics:** Statics, Frictional forces, Dynamics, Conservation of Energy in the body, Heat losses from body, Pressure in the body. Physical properties of bone, Mechanics of joints, muscle contraction and its regulation, Nernst Equation, Goldmann equation	**CR 01**
1-2	**Bioelectricity and Biomagnetism :**Biopotentials- Electric signals from body- EMG, ECG, EEG, EOG, ERG, Magnetic signals from heart and brain – MCG, MEG , PET and characterization instruments based on spectroscopy, echo cardiography	
1-3	**Physics of Hearing :** Basic definition of Audibility, Physics of ear, Mechanoreceptor, Human Audibility Curve, Sensitivity of ear, Testing of hearing, Deafness and hearing aids, Sound in medicine, Sound pollution, Effects of sound pollution on living body, Methods to minimize sound pollution	
1-4	**Physics of Vision**: Optics of eye, Photorecptors, Diffraction effects of eye, Refractive effect in eye and its correction,Contact Lenses, Color vision and chromatic aberration, Instruments used in Ophthalmology	
2-1	**Radiation physics:** Ionizing Radiation and sources, Biological effects of radiation, Interaction of radiation with Bio system	**CR 02**
2-2	**Radiotherapy and Brachytherapy:** Treatment Planning, Radiation protection in therapy	
2-3	**X-ray and Digital Radiography :**Discovery and Production of X-ray, Basic components of X ray machine, X ray dosimetry, Portable and Mobile x ray unit, X-ray in diagnosis, Hazards of X-ray, Digital radiography, Computer tomography (CT Scan), Fluoroscopy	
2-4	**Nuclear Medicine:** Radioactivity and units, Radioactive isotopes and radionuclide, Dosimetry , Scintillation detectors for Thyroid and renal function, Nuclear medicine imaging, Gamma ray scintillation camera, Positron emission tomography, Magnetic resonance imaging (MRI, NMR signals)	
3-1	**Biomaterials** : Biomaterials, Introduction, Bio-ceramics, Bio-polymer, Bio-steel, Bio-chip, Blood as a Biomaterial, Introduction to Bio- Nanomaterial,	**CR 03**
3-2	**New trends in Medical Physics**- Telemedicine, New trends in Medical informatics, Embedded system in Hospital, Laser in medicine	
3-3	**Fundamentals to Biomedical Instrumentation, Patient Safety, Electrodes and Transducers:** Sources and characteristics of bio-signals, Resting and action potential, propagation of action potential, Passive and active conduction, Basic and essentials of biomedical instrumentation system, Problems faced when measuring on human body, Precautions and safety conditions of biomedical instruments, Electric shock hazards-Gross shock Micro current shock, Electrode Theory, Bio potential Electrodes: types and Characteristics, Introduction, Classification and Performance characteristic of transducer, Displacement, position and motion transducer, Transducer for Body temperature measurement	
3-4	**Recording Systems, Cardiovascular System and Measurements:** Basic recording system, General consideration for signal conditioners, Preamplifiers,	

	Differential, Instrumentation, Isolation amplifier	
4-1	**Heart and Cardiovascular system**: Blood Pressure measurement, Pulse oximetry, Block diagram of electrocardiograph, ECG machine maintenance and trouble shooting, The ECG leads, Effect of Artifacts on ECG recording, Introduction to pacemakers, Types of pacemakers, Pacemaker system and its functioning	CR 04
4-2	**The Computer in Biomedical Instrumentation and Biomedical Recorders:** The digital computer-computer hardware-Computer Software, Microprocessors –Types of Microprocessors, Microprocessors in Biomedical instrumentation, Interfacing the computer with medical instrumentation and other equipment, Biomedical computer applications	
4-3	**Nervous system and neural signals :**Introduction to nervous system and neural signals, Neuromuscular transmission, muscle potentials, Electromyography (EMG), EMG recording system, Electroencephalograph (EEG), Block diagram, Computerized Analysis of EEG.	
4-4	**Respiratory system, special care instruments and ultrasonic imaging system:** The Physiology of the respiratory system, Tests and instrumentation of the mechanics of breathing, Respiratory Therapy Equipment, ICU/CCU equipment, Bedside monitor, Physiological Telemetry, Diagnostic and Medical ultrasound, Physics of ultrasonic waves, biological effect of ultrasound, 3D ultrasound imaging system, imaging modes, Basic pulse echo apparatus	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Text-Books			
	-		
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
PHY516 –RB1	Medical Physics -John R. Cameron, J. G. Skofronick, John Wiley and Sons		International Publications
PHY516 –RB2	Radiation Biophysics -Edward Alphan		Prentice Hall Advance Referes
PHY516 –RB3	T.B. of Biophysics, -R.N. Roy		Central Publication
PHY516 –RB4	Clinical Biophysics: Principles and Techniques -P. Narayanan		
PHY516 –RB5	Biomedical Instrumentation and Measurements , -Leslie Cromwell, Fred J. Weibell, Erich A. P.	Second edition	feiffer Pearson Education
PHY516 –RB6	Handbook of Biomedical Instrumentation - R. S. Khandpur .	Second Edition	Tata McGraw Hill
PHY516 –RB7	Biomedical Instrumentation and Measurement - Carr and Brown-Pearson.		
PHY516 –RB8	Biomedical instruments and measurements - R. Ananda Natarajan Eastern economy edition	Second edition	
PHY516 –RB9	A textbook of Biomedical engineering -R.M. Kenedi, blackie		Glasgow & London
PHY516 –RB10	Medical instrumentation: Application and design -John G. Webster, Willey India Education	Third edition	
CD / DVD: Explore additional details and reinforce learning, with this optional learning			

resource!			
PHY516 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
PHY516-WL1			

Course Outcomes

After successful completion of this course, student should be able to

- Apply expert theoretical knowledge and an integrated understanding across all areas of medical physics.
- Utilise advanced problem-solving skills to analyse outputs and synthesise complex information in applying medical physics knowledge into clinical practice.
- Apply advanced theoretical and technical skills to perform and critically evaluate quality assurance procedures for medical physics
- Demonstrate an expert understanding of the roles and responsibilities of medical physicists in patient care and public safety, as part of diverse interdisciplinary teams.
- Interpret the significance and scope of ethical principles and the application of these principles in medical physics.

SEMESTER 03
PHY601: STATISTICAL MECHANICS

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics){2023 Pattern} & V141: M.Sc. (Physics){2022 Pattern}

COURSE INFORMATION

Sem	Major	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
03	DSC	PHY601	Statistical Mechanics	4	12	120	30	70	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • Candidates with B.Sc./ B.Sc.(Physics)/B.Sc.(Electronics)/B.E./B. Tech Degree or Equivalent pass	This course enables the students: • Understand the methods of mathematical physics and to develop required mathematical skills to solve problems in statistical mechanics and other fields of theoretical physics • Explore the concepts in classical laws of thermodynamics and their application • Understand the ensemble theories in statistical mechanics • Introduce partition function and its computation • Understanding of the theory and methods of statistical physics and thermodynamics.

UNITS

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	Introduction to Thermodynamics Thermodynamic Processes and Systems Maxwell's relations Thermodynamic Potentials	CR 01	As per evaluation pattern, on Each Credit, Student is required to answer • Very Short Answer Question (VSAQ), of 03 marks • Short Answer Question (SAQ), of 05 marks • Long Answer Question (LAQ) of 10 Marks (LAQ may contain sub-questions (a), (b) and so on.)
02-01 02-02 02-03 02-04	Conditions of Equilibrium crocanonicalEnsemble Examples of Microcanonical Ensemble Canonical Ensemble	CR 02	
03-01 03-02 03-03 03-04	Grand Canonical Ensemble Quantum Statistical Mechanics Density Matrix Single Particle Quantum Partition Function Harmonic Oscillator Wigner Transformation	CR 03	
04-01 04-02 04-03 04-04	Grand Canonical Formulation of Ideal Gas Bose-Einstein Statistics General Treatment of a Bose gas Bose Gas	CR 04	

DETAILED SYLLABUS

UN	Detailed Syllabus of the Unit	CR
1-1	**Introduction to Thermodynamics**: Laws of Thermodynamics, Second Law of Thermodynamics and Heat Engines, Entropy, Clausius Inequality,	CR 01
1-2	**Thermodynamic Processes and Systems:** Extensivity of Entropy and Internal Energy, Gibbs Duhem relation, Exact and Inexact differentials, Legendre Transformation, Free Energy in Thermodynamics	
1-3	**Maxwell's relations - Part:** Maxwell's relations, Response Functions and manipulating Partial Derivatives, Working With Thermodynamics	
1-4	**Thermodynamic Potentials:** Joule Expansion and Joule Thomson Effect, Stability of Thermodynamic Potentials, Consequences of Stability of Thermodynamic Potentials	
2-1	**Conditions of Equilibrium:** Gibbs Phase Rule, Introduction to Probability, Discrete and Continuous Distributions, Central Limit Theorem and Statistical Entropy, Classical Probability Density and Liouville Equation	CR 02
2-2	**MicrocanonicalEnsemble:** Classical Probability Density, Ergodicity and Microcanonical Ensemble, Microcanonical Ensemble, Examples of Microcanonical Ensemble- Two Level System, Examples of Microcanonical Ensemble- Magnetic System and Ideal Gas	
2-3	**Examples of Microcanonical Ensemble:** Ultra-Relativistic Gas, MicrocanonicalUltrarelativistic Gas and Quantum Solid, Microcanonical Excluded Volume	
2-4	**Canonical Ensemble:** Canonical Ensemble Paramagnet, Canonical Ensemble Ideal Gas, Canonical Ensemble Einstein Solid	
3-1	**Grand Canonical Ensemble:** Grand Canonical Ensemble Ideal Gas - Part I, MicroCanonical to Canonical - Part I, Interacting System - Part I	CR 03
3-2	**Quantum Statistical Mechanics Density Matrix:** Van-Der Waals Equation of State, Quantum Statistical Mechanics Density Matrix, Density Matrix in different Ensembles, Free Particle Quantum Canonical Partition Function Free	
3-3	**Single Particle Quantum Partition Function Harmonic Oscillator:** Single Particle Quantum Partition Function Harmonic Oscillator	
3-4	**Wigner Transformation:** Wigner Transformation, N- Particle partition function, Canonical Formulation of Ideal Gas	
4-1	**Grand Canonical Formulation of Ideal Gas:** Grand Canonical Formulation of Ideal Gas, High Temperature Expansion, Degenerate Fermi Gas, Ideal Fermi Gas close to T=0, Chemical Potential and Specific Heat, Relativistic Fermi Gas at T=0	CR 04
4-2	**Bose-Einstein Statistics:** Ideal Bose Gas, Bose-Einstein Condensation, Pressure of an Ideal Bose Gas, Specific Heat of an Ideal Bose Gas, Bose-Einstein Condensation in a Harmonically Trapped Bose Gas	
4-3	**General Treatment of a Bose gas:** Specific Heat of a Harmonically Trapped Bose Gas, General Treatment of a Bose gas - Part	
4-4	**Bose Gas:** Discontinuity in the Specific Heat of a Bose Gas, Ultra Relativistic Bose Gas Stefan Boltzmann Law	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Text-Books			
PHY601-T01	Statistical Mechanics -Gaurav Kanthe, Umesh Sandhanshiv	2023	YCMOU, Nashik

Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
PHY601 –RB1	Fundamentals of Statistical and Thermal Physics - F.Reif	1985	McGrawHill International
PHY601 –RB2	Fundamentals of Statistical Mechanics, -B.B. Laud,	2003	New Age International Publication
PHY601 –RB3	Statistical Mechanics -R.K. Pathria,	2nd Edition	Bufferworgh Heinemann
PHY601 –RB4	Statistical Mechanics -K. Huang,	2nd Edition	John Willey and Sons
PHY601 –RB5	Statistical Mechanics -SatyaPrakash and KedarNath Ram	2008	Nath Publication
PHY601 –RB6	Statistical Mechanics by Loknathan and Gambhir		
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
PHY601 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
PHY601-WL1	Link for this course: https://nptel.ac.in/courses/115/106/115106126/		

Course Outcomes

After successful completion of this course, student should be able to

- Explore the concepts of Phase space, Macro and Microstate
- Interpret thermodynamic probability
- Illustrate Maxwell-Boltzmann law - distribution of velocity
- Validate Fermi-Dirac distribution law - electron gas and Bose-Einstein distribution law - photon gas
- Describe and apply various aspects of statistical mechanics

PHY602: CONDENSED MATTER PHYSICS

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics){2023 Pattern} & V141: M.Sc. (Physics){2022 Pattern}

COURSE INFORMATION

Sem	Major	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
03	DSC	PHY602	Condensed Matter Physics	4	12	120	30	70	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • Candidates with B.Sc./ B.Sc.(Physics)/B.Sc.(Electronics)/B.E./ B. Tech Degree or Equivalent pass	This course enables the students: • Introduce the basic theoretical concepts of the condensed matter physics. • Understand the knowledge of solid-state physics and to improve their problem-solving ability, including the design of experiments which examine principles in condensed matter physics • Bridge the gap between basic solid state physics and quantum theory of solids. • Solve the problems related to metal-insulator transition and superconductivity • Acquire knowledge of the behaviour of electrons in solids based on classical and quantum theories.

UNITS

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	Solid State Physics Laue equations Brillouin zone Covalent crystals	CR 01	As per evaluation pattern, on Each Credit, Student is required to answer • Very Short Answer Question (VSAQ), of 03 marks • Short Answer Question (SAQ), of 05 marks • Long Answer Question (LAQ) of 10 Marks (LAQ may contain sub-questions (a), (b) and so on.)
02-01 02-02 02-03 02-04	Bonds Structure Sommerfeld theory Fermi-Dirac distribution Thermal conductivity	CR 02	
03-01 03-02 03-03 03-04	Reflection and transmission amplitudes and coefficients Nearly Free Electrons Model Fermienergy and carrier concentration Phonons	CR 03	

04-01 04-02 04-03 04-04	Diamagnetism Paramagnetism Superconductivity Josephson Effect	**CR 04**	

DETAILED SYLLABUS

UN	Detailed Syllabus of the Unit	CR
1-1	**Solid State Physics:** What is solid?, Bravais lattice, Indexing of crystal planes, Simple crystal structures, Diffraction of waves by crystals, Fourier analysis of diffraction, Diffraction condition	**CR 01**
1-2	**Laue equations:** Laue equations and Ewald construction	
1-3	**Brillouin zone:** Brillouin zone, Brillouin zones for bcc and fcc lattice, Fourier analysis of the basis and structure factor, Atomic form factor, Van der Waals attraction, Repulsive interaction, Equilibrium lattice constant and cohesive energy, Ionic crystals, Evaluation of the Madelung constant	
1-4	**Covalent crystals:** Linear combination of atomic orbitals	
2-1	**Bonds Structure:** Electron tunneling in covalentbonds, Metallic bonds, The Drude theory of metals Hall effect and magnetoresistance, AC electrical conductivity, Thermal conductivity	**CR 02**
2-2	**Sommerfeld theory:** Introduction to Sommerfeld theory – I, Introduction to Sommerfeld theory – II, Electronic states at finite temperature	
2-3	**Fermi-Dirac distribution:** Fermi-Dirac distribution, Thermal properties of the free electron gas, The Sommerfeld theory for conduction in metals	
2-4	**Thermal conductivity:** Thermal conductivity, One dimensional chain of atoms, One dimensional chain of atoms, Periodic boundary condition, Energy levels in periodic array of quantum wells, Tunneling of electrons	
3-1	**Reflection and transmission amplitudes and coefficients:** Reflection and transmission amplitudes and coefficients, Transfer matrix for a rectangular barrier, Electron tunneling through a periodic potential, The tight-binding approximation, Tridiagonal matrices and continued fraction	**CR 03**
3-2	**Nearly Free Electrons Model:** Plane-wave basis for nearly free electrons, Nearly free electron approximation, Dynamical aspects of electrons in band theory, Semiconductor crystals	
3-3	**Fermi-energy and carrier concentration:**Effective mass, Carrier concentration, Mobility, impurity conductivity, and Fermi surface, Vibration of crystals with monatomic basis, Analyzing the dispersion relation	
3-4	**Phonons:** Phonons with diatomic basis, Quantization of elastic waves, Phonon heat capacity, Phonon density of states	
4-1	**Diamagnetism:** Introduction to diamagnetism, Issues with the classical theory of diamagnetism, Quantum theory of diamagnetism	**CR 04**
4-2	**Paramagnetism:** The quantum theory of paramagnetism, Rare earth atoms, Hund's rule, Crystal field splitting, Quenching of orbital angular momentum, Paramagnetic susceptibility of conduction electrons, Ferromagnetism, Antiferromagnetism and ferrimagnetism,	

4-3	**Superconductivity**: Introduction to superconductivity, Thermodynamics of superconducting transition,London equation, BCS theory of superconductivity, Flux quantization in a superconducting ring	
4-4	**Josephson Effect:** Single particle tunneling and Josephson effect, AC Josephson effect and microscopic quantum interference	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Text-Books			
	-		
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
PHY602 –RB1	Introduction to solid states Physics, Charles, Kittle	7th Edition	
PHY602 –RB2	Solid States Physics, S.O. Pillai	latest edition	
PHY602 –RB3	Problem in Solid State Physics, S.O. Pillai		
PHY602 –RB4	Solid states Physics, Wahab		
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
PHY602 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
PH132-WL1	Link for this course: https://nptel.ac.in/courses/115/102/115102124/		

Course Outcomes

After successful completion of this course, student should be able to

- Understand about the crystal structure, interaction with X-ray, lattice vibrations, defects, electronic properties and the magnetic properties.
- Investigate the structural and physical properties of materials by developing better understanding of crystal structure with particular emphasis on studying the electrical and magnetic behavior of solids
- Establish various theories of different classes of solids showing varying properties like magnetism, polarization and superconductivity
- Explain the significance and value of condensed matter Physics.

PHY603: QUANTUM MECHANICS- II

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics)) {2023 Pattern} & V141 M.Sc. Physics {2022 Pattern}

COURSE INFORMATION

Sem	Major	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
03	DSC	PHY603	Quantum Mechanics- II	2	06	60	15	35	50	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully completed: • Candidates with B.Sc./ B.Sc.(Physics)/ B.Sc.(Electronics) B.E./ B.Tech Degree or Equivalent pass	This course enables the students: • Understand the fundamentals of quantum physics • Make familiar with various quantum mechanical problems related to rotation and spin angular momenta etc. • Study auantum information and approximation methods in quantum mechanics • Exposure to quantum field theory and universal interactions.

Note: This is OER. Link for this course: https://nptel.ac.in/courses/115/101/115101107/, *https://nptel.ac.in/courses/115/103/115103104/*

UNITS

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	Stern-Gerlach Experiment Addition of Angular Momentum Quantum Physics Density Matrix formalism	CR 01	As per evaluation pattern, on Each Credit, Student is required to answer • Very Short Answer Question (VSAQ), of 03 marks • Short Answer Question (SAQ), of 05 marks • Long Answer Question (LAQ) of 10 Marks (LAQ may contain sub-questions (a), (b) and so on.)
02-01 02-02 02-03 02-04	Rotation and Spin Angular Momentum Quantum Information Approximation methods in Quantum Mechanics Approximation methods and special topics	CR 02	

DETAILED SYLLABUS

UN	Detailed Syllabus of the Unit	CR
1-1	**Stern-Gerlach Experiment**: Oscillator Algebra, Angular Momentum, Rotations Groups	CR 01
1-2	**Addition of Angular Momentum**: Clebsch-GordanCoeffcients, Tensor Operators & Wigner-Eckart Theorem – I	

1-3	**Quantum Physics:** Postulates of Quantum Mechanics, Stern, Gerlach Experiment, Spin Quantization, Young's Double Slit Experiment, The Mathematical Formalism of Quantum Mechanics, Uncertainty Principle, The Density Matrix Formalism, Expectation values of Operators	
1-4	**Density Matrix formalism**: Qunatum Harmonic Oscillator, Creation and annihilation Operators, Coherent States and their Properties, Applications of Coherent States, squeezed states, Symmetries and Conservational Principles in Quantum Mechanics	
2-1	**Rotation and Spin Angular Momentum** : Rotation Operator and Invariance of Angular Momentum, Parity, Spherically Symmetric System and Applications to quantum dots, Spin Angular Momentum, Addition of Angular Momentum, Clebschgordan coefficients, Magnetic Hamiltonian, Heisenberg Model, Introduction to Quantum Computing, Qubits, EPR Paradox	
2-2	**Quantum Information:** Quantum Entanglement (QE), Teleportation, Quantum Teleportation for one spin, Entangled state for two spins, Quantum Gates, Walsh Hadamard Transportation, No cloning theorem	
2-3	**Approximation methods in Quantum Mechanics:** Perturbation Theory, Stark Effect: First order in ground state, Stark Effect: Second order in ground state Variational method, Variation of constants, Upper bound on ground state energy, Application of Variational method, Hydrogen, Helium atom, Comparison with perturbation theory, WKB Approximation, Bohr Sommerfeld quantization condition	**CR 02**
2-4	**Approximation methods and special topics:** Summary of Approximation methods, Time dependent Perturbation Theory, Time dependent Perturbation Theory, Fermi's Golden rule, Einstein's A and B coefficients Scattering Theory, Linear Response Theory: Derivation of Kubo formula, Quantum Dynamics: Two level system Examples, Interaction of Radiation with matter, Landau levels	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Text-Books			
PHY603-T01	Quamtum Mechanics - Manish S Shingare	2023	YCMOU, Nashik
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
PHY603: RB1	A Text-book of Quantum Mechanics –P.M.Mathews and K.Venkatesan.		
PHY603: RB1	Quantum mechanics -A. Ghatak and S. Lokanathan		
PHY603: RB1	Modern Quantum mechanics –J. J.Sakurai		
PHY603: RB1	Introduction to Quantum Mechanics –David J.Griffiths		
PHY603: RB1	Quntum Mechanics -Nouredine Zettili		A John Wiley and Sons, Ltd., Publication
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			

PHY603 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
PHY603-WL1	**https://nptel.ac.in/courses/115/101/115101107/, https://nptel.ac.in/courses/115/103/115103104/**		

Course Outcomes

After successful completion of this course, student should be able to

- Investigate the basic concepts of quantum Mechanics
- Understand the time – dependent and time – independent Schrödinger's equations
- Use perturbation theory to find approximate solutions to more complex quantum mechanical systems
- Learn Eigen values and Eigen functions of operators and computation of Clebsch–Gordan coefficients.
- Explain approximation methods used in Quantum Mechanics

PHY604: PHYSICS- III- PRACTICAL

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics){2023 Pattern} & V141: M.Sc. (Physics){2022 Pattern}

COURSE INFORMATION

Sem	Major	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
03	DSC	PHY604	Physics- III - Practical	4	12	120	50	50	100	P

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • Candidates with B.Sc. / B.Sc.(Physics)/B.Sc.(Electronics)/B.E./B. Tech Degree or Equivalent pass	This course enables the students: • Collect data and revise an experimental procedure iteratively and reflectively • Evaluate the process and outcomes of an experiment quantitatively and qualitatively • Extend the scope of an investigation whether or not results come out as expected

LAB ACTIVITY

UN	Title of Activity	CR
1	To measure resistivity of a semiconductor by four probe method at different temperatures and Determination of band gap.	CR 01
2	To determine Lande's g factor of DPPH using Electron-Spin resonance (E.S.R.) Spectrometer.	
3	To determine the magnetic susceptibility of a paramagnetic sample by measuring the force exerted on the sample by a magnetic field gradient Susceptibility, Gauy method	
4	To determine skin depth in Al using electromagnetic radiation. Skin depth in Al using electromagnetic radiation.	
5	To determine Counting statistics by using G.M. tube.	CR 02
6	To determine End point energy and Absorption coefficient using G.M. tube.	
7	To determine λ Michelson Interferometer.	
8	To determine of thickness of thin transparent sheet like mica using Michelson interferometer	
9	To demonstrate the wave nature of the electron by Electron Diffraction.	
10	To Study of Thermionic Emission.	CR 03
11	To determine wavelength of monochromatic source using Fabry-Parot Etalon.	
12	To measure electrical conductivity of silicon/germanium material at different temperatures by Four Probe method.	

13	Determination of orientation of a crystal by back reflection Laue method.	
14	To measure the superconductivity transition temperature and transition width of high-temperature superconductors.	
15	Determination of wavelength of He-Ne Laser by transmission grating and reflection grating.	CR 04
16	Beam divergence of a Diode Laser	
17	Determination of the diameter of a thin wire using a laser	
18	To determine the dipole moment of a given liquid	
19	To determine magnetic susceptibility of $FeCl_3$	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Text-Books			
PHY604–P01 [PHY125]	Physics-II – Practical, Kapade Sweta Dipakraj	2022	YCMOU, Nashik
PHY604–P02 [PHY133]	Physics –III Practical, Dr.Dewrao M. Pimpalshende	2022	YCMOU, Nashik
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
PHY604 –RB1			
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
PHY604 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
PHY604-WL1			

Course Outcomes

After successful completion of this course, student should be able to

- Collect data and revise an experimental procedure iteratively and reflectively,
- Evaluate the process and outcomes of an experiment quantitatively and qualitatively,
- Extend the scope of an investigation whether or not results come out as expected,
- Communicate the process and outcomes of an experiment, and
- Conduct an experiment collaboratively and ethically.

PHY605: RESEARCH PROJECT

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics){2023 Pattern} & V141: M.Sc. (Physics){2022 Pattern}

COURSE INFORMATION

Sem	Other	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
03	RP	PHY605	Research Project	4	12	120	50	50	100	PW

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • Candidates with B.Sc. / B.Sc.(Physics)/ B.Sc.(Electronics)/B.E./ B. Tech Degree or Equivalent pass	This course enables the students: • Identify and discuss the role and importance of research in the Physics. • Identify and discuss the issues and concepts salient to the research process. • Identify and discuss the complex issues inherent in selecting a research problem, selecting an appropriate research design, and implementing a research project. • Identify and discuss the concepts and procedures of sampling, data collection, analysis and reporting. • Explain key research concepts and issues

GUIDELINES FOR PROJECT

No	Guidelines for the Students and Study Centers for the conduct of Project
1	The “Project Work” course aims to imbibe in students the principle that working is learning. Learning and working are two sides of the same coin and thus, work experience enhances the learning.
2	This course is based on preliminary research oriented topics both in theory and experiment. The subject expert/ counsellor will act as supervisors for the projects. Project shall be on the current and relevant topics and issues. Project topic is jointly finalized by the student and the project supervisors through discussion. At the completion of the project by the semester end, the student will submit a Project Report in the form of Dissertation which will be examined by the examiners. The end examination shall consist of (a) Presentation and (b) Comprehensive viva-voce.
3	Students are expected to work on “Project Work” for about 6 hours per week (About 2 hour’s self-study at residence and 12 hours in counselling session at study centre), during a semester. **Thus only those projects, demanding such study efforts on all those activities, listed in above, should beselected**.
4	**A single student will have to do a project.** Since. The student invests his energy, time and resources in a project. The project therefore

	should, have important focus on some relevant practical aspects. This will help student to justify his efforts on project.
5	Employed Students are allowed to complete "Project Work" in the industry where he/ she is employed or his/ her place of choice. Such a student has to identify a resource person in industry, who can take responsibility of guiding him in project work. Such person should be eligible to work as "ProjectGuide".
6	Study centre should assist unemployed students, in locating sponsored "Projects" from local industries. Students are encouraged to locate sponsored projects from the local industries. **But, in case, a student is unable to locate such project, he is also allowed to complete "Project Work" at his study center**.
7	**The Project Work must involve practical research work related to your selected discipline.**
8	Students have to finance expenditure on "Project"byhisown. Hence students should select those projects, accordingly.
9	Each "Project Guide" may be assigned **maximum** 5 students.
10	The original design requirements **are not essential**, although highly encouraged. Hence, normally, projects should not be repeated. The same project undertaken in recent past, by past students, should be avoided. But it is most important that, students must put his independent study efforts on the project. Thus, student should gain practical project execution knowledge about making some useful product, after he goes through all projects completion steps listed above.
11	There project report should be file bound/spiral bound/hard bound and should have following format • **Title Page/Cover page** • **Certificate endorsed by Project Guide/Supervisor, Learner Support Center Coordinator and Head** • **Declaration for followed ethical practice and non-plagiarism** • **Acknowledgement** • **Abstract of the project** • **Table of Contents** • **List of Figures** • **List of Tables** • **Chapters of Project Report –** **Chapter 1: Introduction**: Background of the project, Need for the project, Brief idea of the project, Literature review, Aims and Objectives of the project **Chapter 2: Design and Methodology:** overview of the complete project, the scientific principles involved in the design of the project, Block Diagrams, Experimental/Theoretical Methodology/Circuit/Model/ materials required, etc. **Chapter 3: Testing, Conductof Experiment/ Module**: Actual conduct of experiment, measurements, observations, etc. **Chapter 4: Analysis of Data:**Analysis of the data and observations received during experimentation **Chapter 5: Results, Discussion and Conclusions:** Discuss why the specifications were not met or the reasons for the failure, if any. Discussed the problems and difficulties encountered and how they were / can be eliminated. Discuss any extension work or modifications, which you want to suggest. **Chapter 6: References**: List the books, reference books, journals, websites, magazines and data manuals used, etc.
12	**Project Report Submission Process**: Student should prepare 2 copies of the Project Report. At the beginning, the respective Project Guide must approve both copies positively before the end examination of Project Work. Then respective Study Center Coordinator approves both copies of the Project Report. Student should submit one of these approved copies to the study center. The student should retain remaining one of these approved copies. Study center should preserve their copy of, all project reports, till the end

	examination of Project Work. **Even student must bring his own copy during this end examination**.
13	**Project Report Format:** 1. **The project report should be printed on only right side of A4 size (210 mm ´ 297 mm) paper. There is no minimum or maximum page number limit for the "Project Report", but report of minimum 50–70 pages is expected. University recommends only flexible binding for the "Project Report". But, if student wishes, he may also use spiral binding.** 2. **Margins should be as follows:·** ▪ **Left Margin : 40mm** ▪ **Right Margin : 20mm** ▪ **Top Margin : 20mm** ▪ **Bottom Margin : 27mm** 3. **Header should not be used. Footer, containing page number at the center should only be used, with footer margin of 25mm.** 4. **Text should be printed in font size of 12 points and at interline distance of 18 points. (That is 1.5 line spacing). Normally, figures should be embedded in the text, where there first reference occurs. But if necessary, figures may be grouped on separate pages. Figure should be numbered as 'Fig C.F', where 'C' is chapter number and 'F' is figure number. Figure number 'F' is reset back to 1 for each new chapter.** **Page Sequence: (1) Cover page as per specimen 1 (2) Certificate page as per specimen 2 (3) Acknowledgement page for the help offered by individuals and institution (4) Content page as per specimen 3. Following suggested scheme of chapters in project report then follows these first 4pages.**

Course Outcomes
After successful completion of this course, student should be able to • Make students familiar with approach to do literature survey • Make student capable of independent thinking • Learn basic techniques for carrying out research

PHY606: PHYSICS OF THIN FILM

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics){2023 Pattern} & V141: M.Sc. (Physics){2022 Pattern}

COURSE INFORMATION

Sem	Major	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
03	DSE	PHY606	Physics of Thin Film	4	12	120	30	70	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • Candidates with B.Sc. / B.Sc.(Physics)/B.Sc.(Electronics)/B.E./B. Tech Degree or Equivalent pass	This course enables the students: • Understand about the difference between bulk and thin film, the mechanical, optical, electrical and magnetic properties of thin film • Understand the principle in measuring the thickness of thin films and to find a suitable method for measuring the thickness of thin films. • Understand and analyze the characteristics of thin films using different instrumentation technique. • Able to understand the nucleation theories leading to the growth. • Understanding the electrical and superconducting behavior of thin films and hence to draw a valuable conclusion regarding the properties of the material

UNITS

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	Introduction to thin films Comparison of thin and thick films Theory of growth of thin films Thin Film Growth	CR 01	As per evaluation pattern, on Each Credit, Student is required to answer • Very Short Answer Question (VSAQ), of 03 marks • Short Answer Question (SAQ), of 05 marks • Long Answer Question (LAQ) of 10 Marks (LAQ may contain sub-questions (a), (b) and so on.)
02-01 02-02 02-03 02-04	Deposition Techniques and Measurement of thickness Thin Film preparation techniques Thin film Preparation by Optical method Techniques for Measurement of film thickness	CR 02	
03-01 03-02 03-03 03-04	Properties of thin films Mechanical properties Optical properties Luminescence	CR 03	

04-01 04-02 04-03 04-04	Applications of Thin Films Junction devices Solar cells As storage devices	CR 04	

DETAILED SYLLABUS

UN	Detailed Syllabus of the Unit	CR
1-1	**Introduction to thin films:** Overview of vacuum techniques.	CR 01
1-2	**Comparison of thin and thick films:** Thin film concept in details, Thick film concept in details.	
1-3	**Theory of growth of thin films**: Nucleation, condensation, Capillarity model, Atomistic model,	
1-4	**Thin Film Growth**: Comparison of models, various stages of film growth.	
2-1	**Deposition Techniques and Measurement of thickness:** Physical Vapour Deposition, Chemical Vapour Deposition	CR 02
2-2	**Thin Film preparation techniques:** Molecular Beam Epitaxy, Sputtering, Spray pyrolysis, Dip coating and Spin coating	
2-3	**Thin film Preparation by Optical method:** Photolithography, Electron – beam deposition, Pulsed Laser Ablation.	
2-4	**Techniques for Measurement of film thickness:** Tolansky technique, Talystep (styles) method, Quartz crystal microbalance, Stress measurement by optical method, Gravimetric method	
3-1	**Properties of thin films**: Electrical Properties- Influence of thickness on the resistivity of thin films, Hall Effect & Magnetoresistance in thin films, Fuch-Sondhemir theory, TCR and its effects., Source of Resistivity in Metallic conductors	CR 03
3-2	**Mechanical properties:** Adhesion & its measurement with mechanical and nucleation methods	
3-3	**Optical properties:** Stress measurement by using optical method. Absorption and transmission	
3-4	**Luminescence:** Chemiluminescence, Crystalloluminescence, Electroluminescence, Mechanoluminescence, Photoluminescence, Radioluminescence, Thermoluminescence, Cathodoluminance, Electroluminance	
4-1	**Applications of Thin Films:** Resistors, capacitors	CR 04
4-2	**Junction devices**: Metal semiconductor junction	
4-3	**Solar cells**: ICs, Optical coating, Thin film sensors (gas and humidity),	
4-4	**As storage devices**: Thin films for informationstorage, electro acoustics and telecommunication.	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Text-Books			
	-		
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
PHY606 –RB1	Thin Film Phenomena, K. L. Chopra		McGraw Hill
PHY606 –RB1	Material Science of Thin Films, M. Ohring,		Academic Press

PHY606 –RB1	Thin Film Process, J. L. Vossen and Kern		Academic Press
PHY606 –RB1	Vacuum Technology, A. Roth	2nd revised edition	North Hollad
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
PHY606 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
PHY606-WL1			

Course Outcomes

After successful completion of this course, student should be able to

- Understand the principle, differences and similarities, advantages, and disadvantages of different thin film deposition techniques.
- Identify potential of thin film preparation method for future thin film application.
- Understand about different instrumentation techniques and to analyze thin film properties to apply for various applications.
- Understand, evaluate and use models for understanding nucleation and growth of thin films.
- Improve problems solving skills related to evaluation of different properties of thin films.

PHY607 : Astronomy and Astrophysics

Programme Information

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics) {2023 Pattern}

Course Information

Sem	Major	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
03	DSE	PHY607	Astronomy and Astrophysics	4	12	120	30	70	100	T

Presumed Knowledge and Learning Objectives

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • Candidates with B.Sc. / B.Sc.(Physics)/B.Sc.(Electronics)/ B.E./B. Tech Degree or Equivalent pass	This course enables the students: • Knowledge, understanding and use of the principles of physics and/or astronomy. • Ability to use reasoning and logic to define a problem in terms of principles of physics. • Ability to use mathematics and computer applications to solve physics and/or astronomy problems.

Units

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	Science and the Universe Orbits and Gravity Radiation and Spectra Other Worlds: An Introduction to the Solar System	CR 01	As per evaluation pattern, on Each Credit, Student is required to answer • Very Short Answer Question (VSAQ), of 03 marks • Short Answer Question (SAQ), of 05 marks • Long Answer Question (LAQ) of 10 Marks (LAQ may contain sub-questions (a), (b) and so on.)
02-01 02-02 02-03 02-04	Cratered Worlds The Giant Planets Comets and Asteroids: Debris of the Solar System The Sun: A Garden-Variety Star	CR 02	
03-01 03-02 03-03 03-04	Analyzing Starlight Celestial Distances The Birth of Stars and the Discovery of Planets outside the Solar System The Death of Stars	CR 03	
04-01 04-02 04-03 04-04	The Milky Way Galaxy Active Galaxies, Quasars, and Supermassive Black Holes The Big Bang Life in the Universe	CR 04	

DETAILED SYLLABUS

UN	Detailed Syllabus of the Unit	CR
1-1	**Science and the Universe :** The Nature of Astronomy, The Nature of Science, The Laws of Nature, Numbers in Astronomy, Consequences of Light Travel Time, A Tour of the Universe, The Universe on the Large Scale, The Universe of the Very Small, A Conclusion and a Beginning, The Sky Above, Ancient Astronomy, Astrology and Astronomy, The Birth of Modern Astronomy	
1-2	**Orbits and Gravity :** The Laws of Planetary Motion, Newton's Great Synthesis, Newton's Universal Law of Gravitation, Orbits in the Solar System, Motions of Satellites and Spacecraft, Gravity with More Than Two Bodies, Earth and Sky, The Seasons, Keeping Time, The Calendar, Phases and Motions of the Moon, Ocean Tides and the Moon, Eclipses of the Sun and Moon	**CR 01**
1-3	**Radiation and Spectra:** The Behavior of Light, The Electromagnetic Spectrum, Spectroscopy in Astronomy, The Structure of the Atom, Formation of Spectral Lines, The Doppler Effect**,** Telescopes, Telescopes Today, Visible-Light Detectors and Instruments, Radio Telescopes, Observations outside Earth's Atmosphere, The Future of Large Telescopes	
1-4	**Other Worlds: An Introduction to the Solar System:** Overview of Our Planetary System, Composition and Structure of Planets, Dating Planetary Surfaces, Origin of the Solar System, The Global Perspective, Earth's Crust, Earth's Atmosphere, Life, Chemical Evolution, and Climate Change, Cosmic Influences on the Evolution of Earth	
2-1	**Cratered Worlds:** General Properties of the Moon, The Lunar Surface, Impact Craters, The Origin of the Moon, Mercury, The Nearest Planets: An Overview, The Geology of Venus, The Massive Atmosphere of Venus, The Geology of Mars, Water and Life on Mars, Divergent Planetary Evolution	
2-2	**The Giant Planets:** Exploring the Outer Planets, The Giant Planets, Atmospheres of the Giant Planets, Ring and Moon Systems Introduced, The Galilean Moons of Jupiter, Titan and Triton, Pluto and Charon, Planetary Rings (and Enceladus)	
2-3	**Comets and Asteroids: Debris of the Solar System** Asteroids, Asteroids and Planetary Defense, The "Long-Haired" Comets, The Origin and Fate of Comets and Related Objects, Meteors, Meteorites: Stones from Heaven, Formation of the Solar System, Comparison with Other Planetary Systems, Planetary Evolution	**CR 02**
2-4	**The Sun: A Garden-Variety Star:** The Structure and Composition of the Sun, The Solar Cycle, Solar Activity above the Photosphere, Space Weather, Sources of Sunshine: Thermal and Gravitational Energy, Mass, Energy, and the Theory of Relativity, The Solar Interior: Theory, The Solar Interior: Observations	
3-1	**Analyzing Starlight:** The Brightness of Stars, Colors of Stars, The Spectra of Stars (and Brown Dwarfs), Using Spectra to Measure Stellar Radius, Composition, and Motion, A Stellar Census, Measuring Stellar Masses, Diameters of Stars, The H–R Diagram	
3-2	**Celestial Distances:** Fundamental Units of Distance, Surveying the Stars, Variable Stars: One Key to Cosmic Distances, The H–R Diagram and Cosmic	**CR 03**

	Distances, The Interstellar Medium, Interstellar Gas, Cosmic Dust, Cosmic Rays, The Life Cycle of Cosmic Material, Interstellar Matter around the Sun	
3-3	**The Birth of Stars and the Discovery of Planets outside the Solar System:** Star Formation, The H–R Diagram and the Study of Stellar Evolution, Evidence That Planets Form around Other Stars, Planets beyond the Solar System: Search and Discovery, Exoplanets Everywhere: What We Are Learning, New Perspectives on Planet Formation, Evolution from the Main Sequence to Red Giants, Star Clusters, Checking Out the Theory, Further Evolution of Stars, The Evolution of More Massive Stars	
3-4	**The Death of Stars:** The Death of Low-Mass Stars, Evolution of Massive Stars: An Explosive Finish, Supernova Observations, Pulsars and the Discovery of Neutron Stars, The Evolution of Binary Star Systems,The Mystery of the Gamma-Ray Bursts , Introducing General Relativity, Spacetime and Gravity, Tests of General Relativity, Time in General Relativity, Black Holes, Evidence for Black Holes, Gravitational Wave Astronomy	
4-1	**The Milky Way Galaxy :** The Architecture of the Galaxy, Spiral Structure, the Mass of the Galaxy, The Center of the Galaxy, Stellar Populations in the Galaxy, The Formation of the Galaxy, The Discovery of Galaxie, Types of Galaxies, Properties of Galaxies, The Extragalactic Distance Scale, The Expanding Universe	**CR 04**
4-2	**Active Galaxies, Quasars, and Supermassive Black Holes:** Quasars, Supermassive Black Holes: What Quasars Really Are, Quasars as Probes of Evolution in the Universe, Observations of Distant Galaxies, Galaxy Mergers and Active Galactic Nuclei, The Distribution of Galaxies in Space, The Challenge of Dark Matter, The Formation and Evolution of Galaxies and Structure in the Universe	
4-3	**The Big Bang:** The Age of the Universe, A Model of the Universe, The Beginning of the Universe, The Cosmic Microwave Background, What Is the Universe Really Made Of?, The Inflationary Universe, The Anthropic Principle	
4-4	**Life in the Universe:** The Cosmic Context for Life, Astrobiology, Searching for Life beyond Earth, The Search for Extraterrestrial Intelligence	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Text-Books			
	-		
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
PHY607 –RB1	Solar Energy Thermal Processes, J.A. Duffie and W.A. Beckman	1980	John Wiley and Sons
PHY607 –RB2	Heat and Thermodynamics, M.W. Zemansky		McGraw Hill Publication
PHY607–RB3	Renewable Energy Sources and Conversion Technology, N.K. Basal, M. Kleeman And S.N. Srinivas	1996	Tata Energy Research Institute, New Delhi
PHY607 –RB4	Renewable Energy Technology: A practical guides of beginners, Chetan Singh Solanki		PHI Learning Private-Ltd., New Delhi

PHY607 –RB5	Non-conventional Energy sources, G. D. RAI		Khanna Publishers, Delhi
PHY607 –RB6	Solar Energy Utilization, G.D.Rai		
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
PHY607 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
PHY607-WL1			

Course Outcomes

- Explain practical application of observational techniques
- Solve problems with scientific reasoning and critical thinking skills
- Understand the impact of astronomical bodies and formations on earth and climate. viii) Communicate astronomical concepts and theories effectively.
- Describe the classification of stars, stellar evolution, interstellar matter, galaxies etc.
- Current understanding and investigation of the basic knowledge about cosmic threats viz., comets, asteroids, meteoroids.

PHY608: ENERGY STUDIES

Programme Information

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics){2023 Pattern} & V141: M.Sc. (Physics){2022 Pattern}

Course Information

Sem	Major	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
03	DSE	PHY607	Energy Studies	4	12	120	30	70	100	T

Presumed Knowledge and Learning Objectives

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • Candidates with B.Sc/ B.Sc.(Physics)/ B.Sc.(Electronics)/B.E./ B. Tech Degree or Equivalent pass	This course enables the students: • Achieve and maintain optimum energy procurement and utilisation, throughout the organization • Minimise energy costs/waste without affecting production & quality. To minimise environmental effects. • Outline the impact of energy utilisation on the environment at local and global levels. • Apply science underlying conventional and sustainable energy sources including nuclear, fossil, wind, solar, biomass and biofuels to propose solutions to the clean and sustainable energy problem. • Understand the physical and chemical factors defining the carbon cycle and be able to relate these to global climate change, and to the readiness of carbon capture and storage technologies.

Units

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	Indian Energy Scenario Various types of energy sources Energy Security Non Renewable Energy sources & Renewable Energy sources	CR 01	As per evaluation pattern, on Each Credit, Student is required to answer • Very Short Answer Question (VSAQ), of 03 marks • Short Answer Question (SAQ), of 05 marks • Long Answer Question (LAQ) of 10 Marks
02-01 02-02 02-03 02-04	Solar Radiation and Its Measurements Basics of Heat transfer Solar Radiation and Its Measurements Selective coatings	CR 02	

03-01 03-02 03-03 03-04	Solar Photovoltaics (SPV) Application of SPV Solar Thermal Devices and Systems Solar Devices	**CR 03**	(LAQ may contain sub-questions (a), (b) and so on.)
04-01 04-02 04-03 04-04	Bio Energy Hydrogen Energy Wind Energy Energy Storage	**CR 04**	

DETAILED SYLLABUS

UN	Detailed Syllabus of the Unit	CR
1-1	**Indian Energy Scenario:** Role of energy in economic development and social transformation, Energy and Gross Domestic product (GDP), Gross National Product (GNP) and its dynamics	
1-2	**Various types of energy sources**: Energy sources and overall energy demand, Availability of energy sources, Energy consumption in various sectors and its changing pattern, projected energy demands	
1-3	**Energy Security:** Energy for security and security of energy, Energy consumption and its Impact on environmental climatic change, Future Energy Option: Sustainable development, Energy crisis, Transition from carbon Free technologies, Parameters of transition, Carbon credits.	**CR 01**
1-4	**Non Renewable Energy sources**: Coal, Oil, Natural gas, Nuclear power, Hydroelectricity, **Renewable Energy sources**: Solar ,Wind, Biomass, Tidal, Ocean wave, Ocean thermal, Geothermal and other , Depletion of energy sources and impact of exponential rise in energy, consumption on economics of India and on international relations.	
2-1	**Solar Radiation and Its Measurements:** Importance of Solar Energy : Nature of solar radiation, Sun as a fusion rector, special distribution of extraterrestrial radiation	
2-2	**Basics of Heat transfer:** Heat and Thermodynamics: Basic units, dimensions, Concept of heat, energy and work, Ideal gas flow, 1st and 2nd law of thermodynamics. **Types of heat transfer**: Conductive, Radiative, Convective	
2-3	**Solar Radiation and Its Measurements:** Importance of Solar Energy: Nature of solar radiation, Sun as a fusion rector, special distribution of extraterrestrial radiation, Estimation of extraterrestrial solar radiation, Radiation on horizontal and titled surfaces, Beam, diffuse, global radiation and their measurement.	**CR 02**
2-4	**Selective coatings**: Ideal characteristics of selective coating for variousapplications, Types of selective coatings, materials and techniques for selective coatings, Effect of selective coating on the efficiency of solar collectors.	
3-1	**Solar Photovoltaics (SPV):** Solar Photovoltaics (SPV) Conversion, Basic principles, Types of solar cell materials, Fabrication of solar photovoltaic cells, solar cell parameters and characteristics, Block diagram of general SPV conversion system and their characteristics, Different configurations	
3-2	**Application of SPV**: Such as street light, water pumps, Radio/TV, Small capacity power generation, Solar Photovoltaic (SPV) Systems Designing : Load estimation, selection of inverters, battery sizing, array sizing	**CR 03**
3-3	**Solar Thermal Devices and Systems**: Different types of collectors, Flat plate	

	collector(Basic principle, construction), Energy balance equation of steady state, Testing, Methods to reduce losses	
3-4	**Solar Devices:** Solar cookers, Domestic hot water system, Solar dryers, solar pond, Solar still, Solar furnace, Solar refrigeration, Solar concentraters, systems based on use of solar concentraters	
4-1	**Bio Energy**: Biomass, Generation and utilization, Property of biomass, Agriculture crop and Forestry residues used as fields. Physical, Chemical and biological conversion of biomass into useful form of energy. Gasification, Biomass gasifiers and types. **Biogas**: Generation of biogas, Aerobic and anaerobic bioconversion process. Substances used to produce biogas, Digesters and their designs, Pyrolysis and gasification, Fermentation process **Biofuels**: Types of biofuels, Production processes, Biofuel applications	**CR 04**
4-2	**Hydrogen Energy:** Hydrogen Fuel : Imortance of Hydrogen as a future fuel, Sources of Hydrogen, Fuel of vehicles, Hydrogen production : Production of Hydrogen by various methods, Direct electrolysis of water, decomposition of water, Biological and biochemical methods of hydrogen production, Hydrogen storage : Gaseous, Cryogenic and Metal hydride. Utilization ofhydrogen : Fuel cell – Principle, construction and applications	
4-3	**Wind Energy:** Introduction, Basic principle of wind energy conversion, Extraction of maximum power from wind and its dependence on various parameters. Wind Mills : Types of wind mills, Vertical axis and Horizontal axis wind mills their performance, Merits and Demerits, Limitations of wind energy conversions	
4-4	**Energy Storage:** Types of energy storage systems: sensible and latent heat storage systems, Electric energy storage systems, Chemical energy storage systems, Heat exchanges, Hydro-storage, solar pond as a energy storage, Green house	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Text-Books			
	-		
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
PHY608 –RB1	Solar Energy Thermal Processes, J.A. Duffie and W.A. Beckman	1980	John Wiley and Sons
PHY608 –RB2	Heat and Thermodynamics, M.W. Zemansky		McGraw Hill Publication
PHY608 –RB3	Renewable Energy Sources and Conversion Technology, N.K. Basal, M. Kleeman And S.N. Srinivas	1996	Tata Energy Research Institute, New Delhi
PHY608 –RB4	Renewable Energy Technology: A practical guides of beginners, Chetan Singh Solanki		PHI Learning Private-Ltd., New Delhi
PHY608 –RB5	Non-conventional Energy sources, G. D. RAI		Khanna Publishers, Delhi
PHY608 –RB6	Solar Energy Utilization, G.D.Rai		
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
PHY608 -CD1			

Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
PHY608-WL1			

Course Outcomes

After successful completion of this course, student should be able to

- Understand the difference between renewable and non-renewable energy resources.
- Define energy;Identify energy sources; Analyse personal energy input and output

SEMESTER 04
PHY609: NUCLEAR AND PARTICLE PHYSICS

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics){2023 Pattern} & V141: M.Sc. (Physics){2022 Pattern}

COURSE INFORMATION

Sem	Major	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
04	DSC	PHY609	Nuclear And Particle Physics	4	12	120	30	70	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • Candidates with B.Sc. / B.Sc.(Phy.)/B.Sc.(Electronics)/B.E./B. Tech Degree or Equivalent pass	This course enables the students: • Introduce the structure and properties of atomic nuclei and elementary particles. It covers topics such as nuclear detectors, accelerators, nuclear decay, nuclear reactions, quarks, leptons, and the standard model of particle physics. • Understand the principles, methodologies, and applications of various nuclear techniques used in scientific research, industry, and medical fields. • Utilize nuclear processes, radiation, and nuclear instrumentation to investigate and analyze various phenomena. • Provide students with an understanding of basic radiation interaction. • Explore the fundamental principle of detection techniques for nuclear physics • Gain in-depth knowledge of radioactive decays, nuclear reactions and elementary particle physics etc.

UNITS

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	Nuclear Interactions and Nuclear Reactions Characteristics of Nucleolus Nuclear Forces Direct and compound nuclear reaction mechanisms	CR 01	As per evaluation pattern, on Each Credit, Student is required to answer • Very Short Answer Question (VSAQ), of 03 marks • Short Answer Question (SAQ), of 05 marks • Long Answer Question (LAQ) of
02-01 02-02 02-03 02-04	Nuclear Models Shell model Nuclear Energy Level Collective model of Bohr and Mottelson	CR 02	

03-01 03-02 03-03 03-04	Nuclear Decay Angular momentum Parity selection rules Gamma decay	**CR 03**	10 Marks (LAQ may contain sub-questions (a), (b) and so on.)
04-01 04-02 04-03 04-04	Elementary Particle Physics Hadrons and leptons Elementary' ideas of CP and CPT invariance Quark model	**CR 04**	

DETAILED SYLLABUS

UN	Detailed Syllabus of the Unit	CR
1-1	**Nuclear Interactions and Nuclear Reactions:**Nucleon - nucleon interaction, Exchange forces and tensor forces , Meson theory of nuclearforces	**CR 01**
1-2	**Characteristics of Nucleolus:** Nucleon - nucleon scattering , Effective range theory , Spin dependence of nuclearforces	
1-3	**Nuclear Forces:** Charge independence and charge symmetry of nuclear forces, Isospin formalism, Yukawa interaction	
1-4	**Direct and compound nuclear reaction mechanisms**: Cross sections in terms of partial wave amplitudes, Compound nucleus, Scattering matrix, Reciprocity theorem, Breit - Wigner one level formula, Resonance scattering	
2-1	**Nuclear Models:** Liquid drop model, Bohr - Wheeler theory of si on Experimental evidence for shell effects	**CR 02**
2-2	**Shell model:** Spin - Orbit coupling - Magic numbers	
2-3	**Nuclear Energy Level**: Angular momenta and parties of nuclear ground states, Qualitative discussion and estimates of transition rates	
2-4	**Collective model of Bohr and Mottelson**: Magnetic moments and Schmidt lines.	
3-1	**Nuclear Decay:** Beta decay, Fermi theory of beta decay, Shape of the beta spectrum , Total decay rate	**CR 03**
3-2	**Angular momentum**: Comparative half – lives, Allowed and forbidden transitions	
3-3	**Parity selection rules**: Selection rules , Two-component theory of neutrino decay Detection and properties of neutrino	
3-4	**Gamma decay**: Multipole transitions in nuclei, Angularmomentum and party selection rules, Internal conversion, Nuclear isomerism	
4-1	**Elementary Particle Physics**: Types of interaction between elementary particles	**CR 04**
4-2	**Hadrons and leptons**: Symmetry andconservation laws	
4-3	**Elementary' ideas of CP and CPT invariance**: Classification of hadrons, Lie algebra, SU (2), SU (3) multiplets.	
4-4	**Quark model**: Gell-Mann, Okubo mass formula forocter and decuplet, hadrons, Charm, bottom and top quarks.	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Text-Books			
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			

PHY609 –RB1	Nuclear Physics and analytical Techniques - Dr. V. Komalamba, Prof. N. Manohara Murthy, Prof. C. NageshwaraRao	2009	BRAOU
PHY609 –RB2	Nuclear Physics, - D.C.Tayal	2008	Himalaya Publishing House
PHY609 –RB3	Nuclear Physics, - S.N.Ghoshal	2008	8121904137, 9788121904131 S. Chand Publishing
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
PHY609 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
PHY609-WL1			

Course Outcomes

After successful completion of this course, student should be able to

- Describe the basic interaction mechanisms for charged particles and electromagnetic radiation and explain the working principles behind detectors and their characteristic properties with respect to energy resolution, efficiency etc
- Identify the mechanism and kinematics of nuclear reactions
- Describe the basic features involved in alpha and beta decays and nuclear forces
- Understand Nuclear Structure, Comprehend Nuclear Reactions, Learn Radioactivity and Decay, Explore Nuclear Energy, Nuclear Medicine, and Develop Computational and Analytical Skills.
- Study the atomic nuclei, their properties, interactions, and the forces that govern them. It explores the fundamental structure and behavior of atomic nuclei, as well as the processes of nuclear reactions and the applications of nuclear phenomena.
- Expose to current research topics, emerging technologies, and recent developments in nuclear physics through lectures, literature reviews, or discussions
- Apply the knowledge of nuclear physics can be valuable for pursuing advanced research or specialized careers in nuclear / radiation areas.

PHY610: ELECTRONIC INSTRUMENTATION

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics){2023 Pattern} & V141: M.Sc. (Physics){2022 Pattern}

COURSE INFORMATION

Sem	Major	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
04	DSC	PHY610	Electronic Instrumentation	4	12	120	30	70	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • Candidates with B.Sc. / B.Sc.(Physics)/ B.Sc. (Electronics)/ B.E./ B. Tech Degree or Equivalent pass	This course enables the students: • Introduce the fundamentals of Electronics Instruments and Measurement • Address the underlying concepts and methods behind Electronics measurements. • Explain basic concepts and definitions in measurement. • Describe the bridge configurations and their applications. • Elaborate discussion about the importance of signal generators and analyzers in Measurement. • Study data acquisition systems and transducers. •

UNITS

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	General Configuration Input- Output Configuration Static Performance Characteristics Dynamic characteristics	CR 01	As per evaluation pattern, on Each Credit, Student is required to answer • Very Short Answer Question (VSAQ), of 03 marks • Short Answer Question (SAQ), of 05 marks • Long Answer Question (LAQ) of 10 Marks (LAQ may contain sub-questions (a), (b) and so on.)
02-01 02-02 02-03 02-04	Resistive Type Displacement Sensors Capacitive Type Displacement Sensors Inductive Type Displacement Sensors Hall Effect Sensors	CR 02	
03-01 03-02 03-03 03-04	Flow measurements Other Flow Metering (measuring) Techniques Temperature measurements Thermocouples	CR 03	

04-01 04-02 04-03 04-04	Signal Conditioning Processing Data Acquisition Systems Digital Display Systems Printers	**CR 04**	

DETAILED SYLLABUS

UN	Detailed Syllabus of the Unit	CR
1-1	**General Configuration:** Examples of instruments and their functional description	**CR 01**
1-2	**Input- Output Configuration:** Methods of correction of unwanted inputs	
1-3	**Static Performance Characteristics:** Accuracy, resolution, sensitivity, hysteresis, errors, their types	
1-4	**Dynamic characteristics:** Generalized mathematical model of measurement System, order of instruments: zero, first, second and higher order. Step, ramp and sinusoidal frequency response of first order instruments (thermistor & thermocouple only)	
2-1	**Resistive Type Displacement Sensors:** Potentiometric linear and rotary (angular), strain gauges- responding to dimensional changes and resistivity change namely electrical and semiconductor type	**CR 02**
2-2	**Capacitive Type Displacement Sensors:** Linear and angular type, responding to change in distance, area and dielectric medium.	
2-3	**Inductive Type Displacement Sensors:** Responding to change in Mutual inductance - LVDT, Self-Inductance, Variable reluctance, Eddy current sensors.	
2-4	**Hall Effect Sensors:** Hall effect sensors for displacement measurement. **Digital (optical) Displacement Sensors:** Rotary and linear and also absolute andincremental (introduction only)	
3-1	**Flow measurements:** Types of flow, Derivation of basic equation of flow - Bernoulli equation **Classification of flow meters:** 1. Quantity flow meter(turbine type and positive displacement (short introduction only), 2. Rate Flow Meter:Head type flow meters- Orifice meter, Venturi tube, Pitot tube and rota-meters	**CR 03**
3-2	**Other Flow Metering (measuring) Techniques:** electromagnetic flow meter, Ultrasonic flow meter, and hot wire anemometer (operating principle without derivation), Mass flow measurement(operating principle without derivation)	
3-3	**Temperature measurements:** Basis of temperature scales **Transduction techniques:** Liquid filled thermometer, Resistance type: Platinum resistance temperature sensor, Thermistors	
3-4	**Thermocouples**: Seebeck effect, Peltier effect &Thompson effect, types of thermocouples: T, E, J, K, R, S, B types. With their ranges, thermocouple laws,high temperature measurement using forced cool junction, Solid state temperature sensors AD-590, IC LM-35. (for both sensors introduction from data sheets), Optical pyrometers: Total and selective radiation	
4-1	**Signal Conditioning Processing:** Signal conditioning of the inputs:	**CR**

	Ratiometric conversion, Logarithmic compression, Instrumentation amplifier using three OpAmps- derivation of equation for output voltage, phase sensitive detection (for LVDT displacement sensors), resistance bridge circuit(s) for platinum resistance thermometer (derivation not expected), Thermocouple amplifier with cold junction temperature compensation, Using solid state temperature sensor(AD-590 or LM-35) or thermistor or diode	**04**
4-2	**Data Acquisition Systems**: Block diagram of generalized data acquisition system, single channel and multichannel data acquisition systems, microcontroller based data acquisition system. Data loggers**,** general block diagram, example of microprocessor based data acquisition system: increasing fuel efficiency of a petrol engine using microprocessor based data loggers, Sample and hold circuits	
4-3	**Digital Display Systems**: Classification of display, LED, LCD & other displays: CRT, neon tubes (short introduction)	
4-4	**Printers:** Classification of printers(Impact and non impact), Dot matrix printers, ink jet printers Laser printers (Principle and functional block diagram only) X-Y chart recorders, thermal printers	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Text-Books			
	-		
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
PHY610 –RB1	Computer based industrial controls, K. Kant		PHI publications
PHY610 –RB2	Process Control Instrumentation Technology - Curtis D. Johnson	8th	Prentice Hall India Pvt. Ltd.
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
PHY610 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
PHY610-WL1			

Course Outcomes

After successful completion of this course, student should be able to

- Recognize the evolution and history of units and standards in Measurements.
- Identify the various parameters that are measurable in electronic instrumentation.
- Employ appropriate instruments to measure given sets of parameters.
- Practice the construction of testing and measuring set up for electronic systems.
- Understand about instrumentation concepts which can be applied to Control systems.
- Relate the usage of various instrumentation standards and data acquisition systems.

PHY611: PHYSICS IV- PRACTICAL

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in/and http://ycmou.digitaluniversity.ac/
2	School	School of Architecture, Science and Technology
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics){2023 Pattern} & V141: M.Sc. (Physics){2022 Pattern}

COURSE INFORMATION

Sem	Major	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
04	DSC	PHY611	Physics IV - Practical	4	12	120	50	50	100	P

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • Candidates with B.Sc./B.Sc.(Physics)/ B.Sc.(Electronics)/B.E./ B. Tech Degree or Equivalent pass	After successful completion of this course, student should be able to • Demonstrate understanding of the different types of Circuits • Understand the functions of OpAmp.

LAB ACTIVITY

UN	Title of Activity	CR
1	To design, build and test absolute value circuits.	CR 01
2	To design, build and test thermocouple amplifier having cold junction temperature compensation.	
3	To design, build and test Instrumentation amplifier for load cell.	
4	Study of IC 7107 as DPM. To design build and test 3 &1/2 DPM for load cell.	
5	To design, build and test displacement sensor using potentiometer, variable capacitor.	CR 02
6	Study of accelerometer module.	
7	To design build and test sample & hold amplifier.	
8	To design, build and test bipolar DAC using binary weighted ladder and Op-amps.	
9	To design, build and test Log amplifier using Op-amps and diodes	
10	To Design, build and test phase sensitive detector.	CR 03
11	Temperature characteristics of thermistors or strain gauge and applications	
12	Characteristics and applications of photo electric devices.(photo diode led)	
13	Study of data acquisition system	
14	Study of LVDT sensor	
15	To determine the specific heat of graphite	CR 04
16	Determination of the yield point and the breaking point of an elastic material	

17	Measurement of resistance by two probe method with variation in temperature.	
18	Development of microstructures by photolithography.	
19	Study of photoluminescence of nanoparticles.	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Text-Books			
PHY611-P01 [PHY138]	Electronic Instrumentation- Practical, Mr. B. N. Kadlag, Mr. D. N. Kadlag	2023	YCMOU, Nashik
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
PHY611–RB1			
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
PHY611 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
PHY611-WL1			

Course Outcomes

After successful completion of this course, student should be able to

- Recognize the evolution and history of units and standards in Measurements.
- Identify the various parameters that are measurable in electronic instrumentation.
- Employ appropriate instruments to measure given sets of parameters.
- Practice the construction of testing and measuring set up for electronic systems.
- Understand about instrumentation concepts which can be applied to Control systems.
- Relate the usage of various instrumentation standards.

PHY612: RESEARCH PROJECT

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics){2023 Pattern}

COURSE INFORMATION

Sem	Other	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
04	RP	PHY612	Reseach Project	6	12	120	75	75	150	PW

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • Candidates with B.Sc. / B.Sc. (Physics)/ B.Sc.(Electronics)/ B.E./B. Tech Degree or Equivalent pass	This course enables the students: • Identify and discuss the role and importance of research in the Physics. • Identify and discuss the issues and concepts salient to the research process. • Identify and discuss the complex issues inherent in selecting a research problem, selecting an appropriate research design, and implementing a research project. • Identify and discuss the concepts and procedures of sampling, data collection, analysis and reporting. • Explain key research concepts and issues

GUIDELINES FOR PROJECT

No	Guidelines for the Students and Study Centers for the conduct of Project
1	The “Project Work” course aims to imbibe in students the principle that working is learning. Learning and working are two sides of the same coin and thus, work experience enhances the learning.
2	This course is based on preliminary research oriented topics both in theory and experiment. The subject expert/ counsellor will act as supervisors for the projects. Project shall be on the current and relevant topics and issues. Project topic is jointly finalized by the student and the project supervisors through discussion. At the completion of the project by the semester end, the student will submit a Project Report in the form of Dissertation which will be examined by the examiners. The end examination shall consist of (a) Presentation and (b) Comprehensive viva-voce.
3	Students are expected to work on “Project Work” for about 6 hours per week (About 2 hour’s self-study at residence and 12 hours in counselling session at study centre), during a semester. **Thus only those projects, demanding such study efforts on all those activities, listed in above, should beselected**.

4	**A single student will have to do a project.** Since. The student invests his energy, time and resources in a project. The project therefore should, have important focus on some relevant practical aspects. This will help student to justify his efforts on project.
5	Employed Students are allowed to complete "Project Work" in the industry where he/ she is employed or his/ her place of choice. Such a student has to identify a resource person in industry, who can take responsibility of guiding him in project work. Such person should be eligible to work as "ProjectGuide".
6	Study centre should assist unemployed students, in locating sponsored "Projects" from local industries. Students are encouraged to locate sponsored projects from the local industries. **But, in case, a student is unable to locate such project, he is also allowed to complete "Project Work" at his study center**.
7	**The Project Work must involve practical research work related to your selected discipline.**
8	Students have to finance expenditure on "Project"byhisown. Hence students should select those projects, accordingly.
9	Each "Project Guide" may be assigned **maximum** 5 students.
10	The original design requirements **are not essential**, although highly encouraged. Hence, normally, projects should not be repeated. The same project undertaken in recent past, by past students, should be avoided. But it is most important that, students must put his independent study efforts on the project. Thus, student should gain practical project execution knowledge about making some useful product, after he goes through all projects completion steps listed above.
11	There project report should be file bound/spiral bound/hard bound and should have following format • **Title Page/Cover page** • **Certificate endorsed by Project Guide/Supervisor, Learner Support Center Coordinator and Head** • **Declaration for followed ethical practice and non-plagiarism** • **Acknowledgement** • **Abstract of the project** • **Table of Contents** • **List of Figures** • **List of Tables** • **Chapters of Project Report –** **Chapter 1: Introduction**: Background of the project, Need for the project, Brief idea of the project, Literature review, Aims and Objectives of the project **Chapter 2: Design and Methodology:** overview of the complete project, the scientific principles involved in the design of the project, Block Diagrams, Experimental/Theoretical Methodology/Circuit/Model/ materials required, etc. **Chapter 3: Testing, Conductof Experiment/ Module**: Actual conduct of experiment, measurements, observations, etc. **Chapter 4: Analysis of Data:**Analysis of the data and observations received during experimentation **Chapter 5: Results, Discussion and Conclusions:** Discuss why the specifications were not met or the reasons for the failure, if any. Discussed the problems and difficulties encountered and how they were / can be eliminated. Discuss any extension work or modifications, which you want to suggest. **Chapter 6: References**: List the books, reference books, journals, websites, magazines and data manuals used, etc.
12	**Project Report Submission Process**: Student should prepare 2 copies of the Project Report. At the beginning, the respective Project Guide must approve both copies positively before the end examination of Project Work. Then respective Study Center Coordinator approves both copies of the Project Report. Student should submit one of these approved

	copies to the study center. The student should retain remaining one of these approved copies. Study center should preserve their copy of, all project reports, till the end examination of Project Work. **Even student must bring his own copy during this end examination**.
13	**Project Report Format:** 3. **The project report should be printed on only right side of A4 size (210 mm ´ 297 mm) paper. There is no minimum or maximum page number limit for the "Project Report", but report of minimum 50–70 pages is expected. University recommends only flexible binding for the "Project Report". But, if student wishes, he may also use spiral binding.** 4. **Margins should be as follows:·** ▪ **Left Margin : 40mm** ▪ **Right Margin : 20mm** ▪ **Top Margin : 20mm** ▪ **Bottom Margin : 27mm** 5. **Header should not be used. Footer, containing page number at the center should only be used, with footer margin of 25mm.** 6. **Text should be printed in font size of 12 points and at interline distance of 18 points. (That is 1.5 line spacing). Normally, figures should be embedded in the text, where there first reference occurs. But if necessary, figures may be grouped on separate pages. Figure should be numbered as 'Fig C.F', where 'C' is chapter number and 'F' is figure number. Figure number 'F' is reset back to 1 for each new chapter.** **Page Sequence: (1) Cover page as per specimen 1 (2) Certificate page as per specimen 2 (3) Acknowledgement page for the help offered by individuals and institution (4) Content page as per specimen 3. Following suggested scheme of chapters in project report then follows these first 4pages.**

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Text-Books			
	-		
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			

Course Outcomes

After successful completion of this course, student should be able to

- Make students familiar with approach to do literature survey
- Make student capable of independent thinking
- Learn basic techniques for carrying out research

PHY613: PHYSICS OF NANO MATERIALS

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics){2023 Pattern} & V141: M.Sc. (Physics){2022 Pattern}

COURSE INFORMATION

Sem	Major	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
04	DSE	PHY613	Physics of Nano Materials	4	12	120	30	70	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • Candidates with B.Sc. / B.Sc.(Physics)/ B.Sc.(Electronics)/ B.E./B. Tech Degree or Equivalent pass	This course enables the students: • Understand and use the properties of Nano-materials in diverse fields. • Gain knowledge about the Nanomaterials, their properties, behavior, interaction and use of them over many discipline of science. • Understand the physics of Nanomaterials in detail and to explore the wide application in industry. • Synthesize the effect of dimensionality of the object at nanoscale on their properties

UNITS

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	Quantum Size Effects Electron Confinement Properties of Nano Materials Structural Properties of Nano Materials	CR 01	As per evaluation pattern, on Each Credit, Student is required to answer • Very Short Answer Question (VSAQ), of 03 marks • Short Answer Question (SAQ), of 05 marks • Long Answer Question (LAQ) of 10 Marks (LAQ may contain sub-questions (a), (b) and so on.)
02-01 02-02 02-03 02-04	Physical & Chemical Methods for the Synthesis of Nanomaterials Techniques For Synthesis Of Nanomaterials Synthesis of nanoparticles Method for nanoparticles Synthesis	CR 02	
03-01 03-02 03-03 03-04	Carbon Nanomaterials Porous Material Aerogels Functional Nanomaterials	CR 03	
04-01 04-02 04-03 04-04	Mechanical Properties Thermal & Electrical Properties Optical & Magnetic Properties Applications of Nanomaterials	CR 04	

DETAILED SYLLABUS

UN	Detailed Syllabus of the Unit	CR
1-1	**Quantum Size Effects:** Effect of reduction of dimensions, Quantum size effect.	CR 01
1-2	**Electron Confinement:** Particle in a box, Density of states for a zero, one, two, and three dimensional box.	
1-3	**Properties of Nano Materials:** Surface& Interface effects, Surface energy & Surface curvature, Sintering, Ostwald ripening and Agglomeration.	
1-4	**Structural Properties of Nano Materials:** Electrostatic and Steric Stabilization. Introduction to nano-sized materials & structures	
2-1	**Physical & Chemical Methods for the Synthesis of Nanomaterials:** High energy Ball Milling, Melt mixing.	CR 02
2-2	**Techniques For Synthesis Of Nanomaterials:** Physical techniques, Chemical techniques, biological techniques and Hybrid techniques for synthesis of Nanomaterials**.**	
2-3	**Synthesis of nanoparticles:** By Wet Chemical method (colloidal route), Electrochemical Method	
2-4	**Method for nanoparticles Synthesis:** Langmuir-Blodgett method, Sol-gel method and Hydro thermal method	
3-1	**CarbonNanomaterials:** Fullerene, Carbon nanotubes, Types and Structures of Carbon nanotubes, Synthesis of Carbon Nanotubes, Growth Mechanism, Graphene,	CR 03
3-2	**Porous Material:** Porous silicon, how to make silicon porous, Mechanism of pores formation, Properties of porous silicon morphology	
3-3	**Aerogels:** Types of Aerogels, Properties of Aerogels, Applications of Aerogels	
3-4	**Functional Nanomaterials**: Passivation of quantum dots by core-shell structures,Nano- composites	
4-1	**Mechanical Properties:** Structural properties, Melting of nano materials	CR 04
4-2	**Thermal & Electrical Properties:** Resistivity, Electrical conductivity, temperature coefficient of resistance, dielectric strength and thermoelectricity.	
4-3	**Optical & Magnetic Properties**: Reflection, transmission, absorption, and light emission of the nanomaterials, Surface Plasmon Resonance and Super-paramagnetism.	
4-4	**Applications of Nanomaterials:** Application to Nanoelectronics, Super capacitors, Quantum Dots & Quantum well devices, (QD sensitized solar cells and dye-sensitized Solar cells), Optical Devices, Medical, Biological, Automobiles, Space, Defence, Sports & Cosmetics.	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Text-Books			
	-		
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
PHY613 –RB1	Nanotechnology: Principles & Practices, Sulbha K. Kulkarni		Capital Pub.
PHY613 –RB2	Nanostructures & Nanomaterials Synthesis,		Imperials college

	Properties & Applications, GuozhongCao		Press London
PHY613 –RB3	Nanomaterials: Synthesis, Properties & Applications. Edited by A.S. Edelstein & R.C. Commorata.		Institute of Physics Publishing, Bristol & Philadelphia
PHY613 –RB4	Nano: The Essentials, T.Pradeep ,		McGraw Hill Education
PHY613 –RB5	Nanotechnology: Fundamentals and Applications, Manasi Karkare	2008	I.K.International Pvt. Ltd, New Delhi
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
PHY613 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
PHY613-WL1			

Course Outcomes

After successful completion of this course, student should be able to

- Understand in broad outline of Nanoscience and Nanotechnology.
- Explain the effects of quantum confinement on the electronic structure and corresponding physical and chemical properties of materials at nanoscale
- Correlate properties of nanostructures with their size, shape and surface characteristics.
- Choose appropriate synthesis technique to synthesize quantum nanostructures of desired size, shape and surface properties
- Focus on the design and development of efficient innovative nanostructured materials prepared by various methodologies and physicochemical characterization for technological applications
- Explore the various applications of nanomaterials

PHY614: General Relativity & Cosmology

Programme Information

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics){2023 Pattern}

Course Information

Sem	Major	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
04	DSE	PHY614	General Relativity & Cosmology	4	12	120	30	70	100	T

Presumed Knowledge and Learning Objectives

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • Candidates with B.Sc. / B.Sc.(Physics)/ B.Sc.(Electronics)/ B.E./B. Tech Degree or Equivalent pass	This course enables the students: • Introduce students to General Relativity • Experimental evidence in favour of General Relativity, and the application of General Relativity to the phenomenon of gravitational collapse, • Study of black holes, gravitational waves and topics in cosmology

Units

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04 01-05	Essentials of general relativity Astrophysical relativity The isotropic universe Gravitational lensing The age and distance scales	CR 01	As per evaluation pattern, on Each Credit, Student is required to answer • Very Short Answer Question (VSAQ), of 03 marks • Short Answer Question (SAQ), of 05 marks • Long Answer Question (LAQ) of 10 Marks (LAQ may contain sub-questions (a), (b) and so on.)
02-01 02-02 02-03 02-04	Quantum mechanics and relativity Quantum field theory The standard model and beyond The hot big bang	CR 02	
03-01 03-02 03-03 03-04 03-05	Topological defects Inflationary cosmology Matter in the universe Galaxies and their evolution Active galaxies	CR 03	
04-01 04-02 04-03 04-04	Dynamics of structure formation Cosmological density fields Galaxy formation Cosmic background fluctuations	CR 04	

DETAILED SYLLABUS

UN	Detailed Syllabus of the Unit [Consult Subject Expert to merge 2 Units, So that Total units =16]	CR
1-1	**Essentials of general relativity**: The concepts of general relativity, The equation of motion, Tensors and relativity, The energy–momentum tensor, The field equations, Alternative theories of gravity, Relativity and differential geometry	
1-2	**Astrophysical relativity**: Relativistic fluid mechanics, Weak fields, Gravitational radiation, The binary pulsar, Black holes, Accretion onto black holes	
1-3	Part 2: Classical cosmology : **The isotropic universe**: The Robertson–Walker metric, Dynamics of the expansion,Common big bang misconceptions, Observations in cosmology, The anthropic principle	CR 01
1-4	**Gravitational lensing**: Basics of light deflection, Simple lens models,General properties of thin lenses,Observations of gravitational lensing, Microlensing,Dark-matter mapping	
1-5	**The age and distance scales**: The distance scale and the age of the universe, Methods for age determination, Large-scale distance measurements, The local distance scale, Direct distance determinations	
2-1	Part 3: Basics of quantum fields **Quantum mechanics and relativity**: Principles of quantum theory, The Dirac equation, Symmetries, Spinors and complex numbers	
2-2	**Quantum field theory**: Quantum mechanics of light, Simple quantum electrodynamics, Lagrangians and fields, Interacting fields, Feynman diagrams, Renormalization, Path integrals	
2-3	**The standard model and beyond**: Elementary particles and fields,Gauge symmetries and conservation laws,The weak interaction, Non-Abelian gauge symmetries, Spontaneous symmetry breaking, The electroweak model, Quantum chromodynamics, Beyond the standard modelm, Neutrino masses and mixing, Quantum gravity, Kaluza–Klein models, Supersymmetry and beyond	CR 02
2-4	Part 4: The early universe **The hot big bang**: Thermodynamics in the big bang, Relics of the big bang, The physics of recombination, The microwave background, Primordial nucleosynthesis, Baryogenesis	
3-1	**Topological defects**: Phase transitions in cosmology, Classes of topological defect, Magnetic monopoles, Cosmic strings and structure formation	
3-2	**Inflationary cosmology**: General arguments for inflation, An overview of inflation, Inflation field dynamics, Inflation models, Relic fluctuations from inflation	
3-3	Part 5: Observational cosmology **Matter in the universe**: Background radiation, Intervening absorbers, Evidence for dark matter, Baryonic dark matter, Nonbaryonic dark matter	CR 03
3-4	**Galaxies and their evolution**: The galaxy population, Optical and infrared observations, Luminosity functions, Evolution of galaxy stellar populations, Galaxy counts and evolution, Galaxies at high redshift	

3-5	**Active galaxies**: The population of active galaxies, Emission mechanisms, Extended radio sources, Beaming and unified schemes, Evolution of active galaxies, Black holes as central engines, Black hole masses and demographics	
4-1	Part 6: Galaxy formation and clustering **Dynamics of structure formation**: Overview, Dynamics of linear perturbations, The peculiar velocity field, Coupled perturbations, The full treatment, Transfer functions, N-body models , Nonlinear models	**CR 04**
4-2	**Cosmological density fields**: Preamble, Fourier analysis of density fluctuations, Gaussian density fields, Nonlinear clustering evolution, Redshift-space effects, Low-dimensional density fields, Measuring the clustering spectrum, The observed clustering spectrum, Non-Gaussian density fields, Peculiar velocity fields	
4-3	**Galaxy formation**: The sequence of galaxy formation, Hierarchies and the Press–Schechter approach, Cooling and the intergalactic medium, Chemical evolution of galaxies, Biased galaxy formation	
4-4	**Cosmic background fluctuations**: Mechanisms for primary fluctuations, Characteristics of CMB anisotropies, Observations of CMB anisotropies	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Text-Books			
	-		
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
PHY614 –RB1	*Cosmological Physics,* - Peacock, John A.	1998	Cambridge University Press, 9780521422703
PHY614 –RB2	General Relativity and Cosmology, -J. V. Narlikar Delhi		Macmillan company of India Ltd.
PHY614 –RB3	General Relativity, -I. R. Kenyon		Oxford university press.
PHY614 –RB4	Classical Theory of Fields, Vol. 2, -L. D. Landau and E. M. Lifshitz, Oxford		Pergamon Press.
PHY614 –RB5	First course in general relativity, -B. F. Schutz Cambridge:		Cambridge university press.
PHY615 –RB5	Introduction to Cosmology -J. V. Narlikar	3rd Edition	Cambridge University Press
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
PHY615 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
PHY615-WL1			

Course Outcomes
After successful completion of this course, student should be able to • Gain familiarity with basic concepts from differential geometry and apply them in studying General Relativity • Apply and solve Einstein equations for systems such as a spherically symmetric star, black hole, and an isotropic and homogeneous Universe • Apply their understanding of General Relativity to current areas of research such as gravitational waves

PHY615: ENERGY FROM WASTE

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nasik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in
2	School	School of Sciences
3	Discipline	Science
4	Level	PG
5	Course Used in	V153: M.Sc.(Physics){2023 Pattern}

COURSE INFORMATION

Sem	Major	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
04	DSE	PHY615	Energy from Waste	4	12	120	30	70	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • Candidates with B.Sc./ B.Sc.(Physics)/ B.Sc.(Electronics)/B.E./ B. Tech Degree or Equivalent pass	This course enables the students: • to understand of the concept of energy form waste. • Link legal, technical and management principles for production of energy form waste. • Learn about the best available technologies for energy form waste . • Analyze of case studies for understanding success and failures. • Facilitate the students in developing skills in the decision making process

UNITS

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	Basics Thermochemical conversion processes Combustion and Gasification Technology Pyrolysis Technology	CR 01	As per evaluation pattern, on Each Credit, Student is required to answer • Very Short Answer Question (VSAQ), of 03 marks • Short Answer Question (SAQ), of 05 marks • Long Answer Question (LAQ) of 10 Marks (LAQ may contain sub-questions (a), (b) and so on.)
02-01 02-02 02-03 02-04	Introduction to Energy from Waste (MSW) Waste to energy options Properties of Municipal Solid Waste (MSW): MSW technologies	CR 02	
03-01 03-02 03-03 03-04	Conversion devices Properties of fuels derived from waste to energy technology Power generation using waste to energy technologies Landfills	CR 03	
04-01 04-02 04-03 04-04	Demonstration of LFG Parameters contributing to LFG production Design of nonlandfill Non-landfill technologies	CR 04	

DETAILED SYLLABUS

UN	Detailed Syllabus of the Unit	CR
1-1	**Basics:** Definition of chemical and physical properties and characteristics of MSW a Fuel Comparison to conventional fuels (coal, oil, and natural gas), Resource characterization and assessment	CR 01
1-2	**Thermochemical conversion processes**: Principles of thermochemical conversion processes- Pyrolysis, Gasification, and Combustion	
1-3	**Combustion and Gasification Technology:** Description of main combustion technology, Design of combustion, Co-firing, Energy conversion systems and CHP Description of main gasification technology, Design of gasification, Definition of synthesis gas (producer gas), Co-gasification and IGCC	
1-4	**Pyrolysis Technology:** Description of main pyrolysis technology, Slow pyrolysis for char production, Fast pyrolysis for bio-oil production, Bio-oil upgrading	
2-1	**Introduction to Energy from Waste (MSW):** Characterization and classification of waste as fuel – agrobased, forest residues, industrial waste, Municipal solid waste.	CR 02
2-2	**Waste to energy options**: combustion (unprocessed and processed fuel), gasification, anaerobic digestion, fermentation, pyrolysis	
2-3	**Properties of Municipal Solid Waste (MSW**): Understand the properties (physical, chemical, and biological) commonly associated with Municipal Solid Waste (MSW) and integrate them into waste management calculations	
2-4	**MSW technologies**: MSW segregation technologies and by products; Landfill technology and limitations	
3-1	**Conversion devices:** Combustors (Spreader Stokes, Moving grate type, fluidized bed), gasifier, digesters. Briquetting technology: Production of RDF and briquetted fuel.	CR 03
3-2	**Properties of fuels derived from waste to energy technology:** Producer gas, Biogas, Ethanol and Briquettes, Comparison of properties with conventional fuels.	
3-3	**Power generation using waste to energy technologies**: Cl and Sl engines. IGCC and IPCC concepts.	
3-4	**Landfills:** Gas generation and collection in landfills, Introduction to transfer stations. Comparison with nonenergy options like Vermiculture, Composting.	
4-1	**Demonstration of LFG:** Demonstrate an in-depth knowledge of why and how to control, collect, and treat landfill gas (LFG)	CR 04
4-2	**Parameters contributing to LFG production:** Appraise the parameters contributing to LFG production and composition, the risks and production controls and calculate their potential impact	
4-3	**Design of nonlandfill**: Treatment processes: Evaluate specific process parameters critical to the design of nonlandfill treatment processes (e.g. thermal destruction efficiencies; flue gas desulphurization requirements)	
4-4	**Non-landfill technologies**: Apply process science and engineering (PSE) knowledge in describing key issues regarding emissions, treatment and performance of non-landfill technologies.	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Text-Books			
	-		
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
PHY615 –RB1	Waste-to-Energy: Technologies and Project Implementation, Marc J Rogoff Dr and Francois Screve.		
PHY615 –RB2	Waste to Energy Conversion Technology (Woodhead Publishing Series in Energy), Naomi B Klinghoffer and Marco J Castaldi		
PHY615 –RB3	Waste to Energy: Opportunities and Challenges for Developing and Transition Economies (Green Energy and Technology), Avraam Karagiannidis		
PHY615 –RB4	Waste to Energy, SethiAmrinder Singh		
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
PHY615 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
PHY615-WL1			

Course Outcomes

After successful completion of this course, student should be able to

- Apply the knowledge about the operations of Waste to Energy Plants.
- Analyse the various aspects of Waste to Energy Management Systems.
- Carry out Techno-economic feasibility for Waste to Energy Plants.
- Apply the knowledge in planning and operations of Waste to Energy plants.

End of Document