।। सा विद्या या विमुक्तये ।।
स्वामी रामानंद तीर्थ मराठवाडा विद्यापीठ, नांदेड
"ज्ञानतीर्थ" परिसर, विष्णुपूरी, नांदेड - ४३१६०६ (महाराष्ट्र)
SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY NANDED
"Dnyanteerth", Vishnupuri, Nanded - 431606 Maharashtra State (INDIA)
Established on 17th September 1994 – Recognized by the UGC U/s 2(f) and 12(B), NAAC Re-accredited with 'A' Grade
ACADEMIC (1-BOARD OF STUDIES) SECTION
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प्रस्तुत विद्यापीठीय संकुलातील विज्ञान व तंत्रज्ञान विद्याशाखेतील पदव्युत्तर स्तरावरील द्वितीय वर्षाचे CBCS Pattern नुसारचे अभ्यासक्रम शैक्षणिक वर्ष २०२०—२१ पासून लागू करण्याबाबत.

प रि प त्र क

या परिपत्रकान्वये सर्व संबंधितांना कळविण्यात येते की, **दिनांक २० जून २०२० रोजी संपन्न झालेल्या ४७व्या मा. विद्या परिषद बैठकीतील विषय क्र.११/४७—२०२०** च्या ठरावानुसार **प्रस्तुत विद्यापीठीय संकुलातील विज्ञान व तंत्रज्ञान विद्याशाखेतील पदव्युत्तर स्तरावरील द्वितीय वर्षाचे** खालील विषयांचे **C.B.C.S. (Choice Based Credit System) Pattern** नुसारचे अभ्यासक्रम शैक्षणिक वर्ष २०२०—२१ पासून लागू करण्यात येत आहेत.

01. M.Sc.-II Year-Botany
02. M.Sc.-II Year-Analytical Chemistry
03. M.Sc.-II Year-Industrial Chemistry
04. M.Sc.-II Year-Medicinal Chemistry
05. M.Sc.-II Year-Organic Chemistry
06. M.Sc.-II Year-Physical Chemistry
07. M.Sc.-II Year-Polymer Chemistry
08. M.Sc.-II Year-Computer Application
09. M.Sc.-II Year-Computer Network
10. M.Sc.-II Year-Computer Science
11. M.C.A.-II Year (Master of Computer Applications)
12. M.Sc.-II Year-Environmental Science
13. M.A./M.Sc.-II Year-Geography
14. M.Sc.-II Year-Geophysics
15. M.Sc.-II Year-Geology
16. M.A./M.Sc.-II Year-Mathematics
17. M.Sc.-II Year-Microbiology
18. M.Sc.-II Year-Physics
19. M.Sc.-II Year-Zoology
20. M.Sc.-II Year-Biotechnology
21. M.A./M.Sc.-II Year-Statistics

सदरील परिपत्रक व अभ्यासक्रम प्रस्तुत विद्यापीठाच्या **www.srtmun.ac.in** या संकेतस्थळावर उपलब्ध आहेत. तरी सदरील बाब ही सर्व संबंधितांच्या निदर्शनास आणून द्यावी.

'ज्ञानतीर्थ' परिसर,
विष्णुपुरी, नांदेड – ४३१ ६०६.
जा.क्र.: शैक्षणिक—१/परिपत्रक/पदव्युत्तर(संकुल)—सीबीसीएस अभ्यासक्रम/२०२०—२१/**५१३**

स्वाक्षरित/—
उपकुलसचिव
शैक्षणिक (१—अभ्यासमंडळ) विभाग

दिनांक : ०८.०८.२०२०.

प्रत माहिती व पुढील कार्यवाहीस्तव :
१) मा. कुलसचिव यांचे कार्यालय, प्रस्तुत विद्यापीठ.
२) मा. संचालक, परीक्षा व मूल्यमापन मंडळ यांचे कार्यालय, प्रस्तुत विद्यापीठ.
३) मा. संचालक, सर्व संबंधित संकुले, प्रस्तुत विद्यापीठ.
४) साहाय्यक कुलसचिव, पदव्युत्तर विभाग, प्रस्तुत विद्यापीठ.
५) उपकुलसचिव, पात्रता विभाग, प्रस्तुत विद्यापीठ.
६) सिस्टम एक्सपर्ट, शैक्षणिक विभाग, प्रस्तुत विद्यापीठ.

SWAMI RAMANAND TEERTH MATHAWADA UNIVERSITY, NANDED

Syllabus of M. Sc. S. Y. Physics (CBCS) (Campus School)

(Effective from the Academic Year 2020-2021)

Disclaimer

Syllabus of ***M. Sc. Second Year (Semesters III and IV) Physics (Campus School)*** *given in this document was prepared following requirements of the* ***Choice Based Credit System (CBCS)*** *pattern as recommended by* ***UGC, New Delhi,*** *and has been duly approved by the* ***Faculty of Science and Technology, the Academic Council*** *and the* ***Management Council*** *of* ***S.R.T.M. University****. The same has been implemented from the academic year* ***2020-2021****.*

The Board of Studies in Physics of S. R. T. M. University, Nanded is as follows

Dr. M. K. Patil, ***Chairman, BOS*** ***Director and Professor,*** School of Physical Sciences, S.R.T.M. University, Nanded Contact No. 08308298063 Email: patil@associates.iucaa.in	**Dr. S. N. Keshatti,** Department of Physics, Shivaji Mahavidyalaya, Parbhani Contact No. 9422743448 Email: keshatti.shrinivas@gmail.com
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Ms. Aishwarya V. Patil, *Invitee Member, Students Representative (UG)*	**Mr. Nand Kiran Kishor,** *Invitee Member, Students Representative (PG)*

Syllabus of **M Sc Second Year (*Sem III and IV*) Physics** given in this booklet was prepared by the faculty of the School of Physical Sciences, S.R.T.M. University, Nanded following model curriculum proposed by UGC, New Delhi and looking at the needs of the students to compete with the recent trends in higher education at national and international level. The same has been finalized by inviting comments, suggestions from experts in individual courses from various universities, institutes, industries and alumni of the School, which was then approved by the regular **Board of Studies (BOS) in Physics**, the **Faculty of Science & Technology**, and the **Academic Council of the University**. Following members were invited for preparing draft of the syllabi of various courses:

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Preamble:

Swami Ramanand Teerth Marathwada University, Nanded since its establishment has been trying hard to enhance the education quality in its jurisdiction. In this endeavor the University has taken several initiatives for improving its academic standard, which include periodic up gradation and revision of the curricula in tune with the requirement at global level, using innovative methods in teaching-learning process, imparting skill based value added education, improvisation in the examination and evaluation processes, etc. These measures have found to be very effective in achieving **3Es, the *equity, efficiency and excellence*** in higher education of this region. However, the diversified approaches followed by different faculties and universities within India puts a limit on bringing the global equality in higher education across the country. This is because most of the universities in India follow conventional method of awarding percentage of marks for the performance of the students in their semester end examinations, in contrast to the grades awarded by the institutions of national reputes like IITs, IISERs, IISc and central universities. The scheme of conversion of the scores from percentage to point based grades and letter grades vary widely across the institutions and universities, which in turn produces a wide range of disparity and difficulty while comparing performances of students graduating from different universities and institutes.

To overcome the anomalies relating to the performance assessment of candidates graduating from different universities UGC in recent past has undertaken an exercise of restructuring the curricula of different courses offered by various universities across the country. Though academic flexibility and autonomy is provided to the universities to design their own examination and evaluation methods best suiting the curricula and teaching–learning methods adopted in conducted and affiliated colleges, there is a global need to devise a sensible mechanism for awarding grades to the performance of students. As a result the UGC, New Delhi has suggested all the universities to adopt the grading system of computing the ***cumulative grade point average*** **(CGPA)** for assessing academic performance of the students in the university examinations. This is important not only to compare the performances of the students graduating from different universities but also provide mobility to the students in joining different institutions within India as well as in other countries. The common grading system followed by different universities also enables the potential employers to assess performances of candidates uniformly. As a result S.R.T.M.U. has adopted the ***cumulative grade point average*** **(CGPA)** system

for assessing performance of the students from the academic year 2014-2015. Further, following the guidelines of UGC, New Delhi and looking at the better employability, entrepreneurship possibilities and also to enhance the latent skills of the students SRTMU has also adopted the ***Choice Based Credit System*** **(CBCS)** at graduate as well as post-graduate level. The CBCS system offers flexibility to the students in choosing courses of their own choice from the exhaustive list comprising core, elective, skill based, specializations and minor components that are evaluated following the grading system. The revised syllabus of M. Sc. Second Year Physics given in this document shall be implemented by the University from the academic year 2020-2021.

Master of Science (M Sc) Physics is a post graduation, two year, four semester course of S.R.T.M. University, Nanded. The Credit Based Grading System (CBCS) adopted under this course enables its stakeholders (the students) to develop a strong foundation of the fundamental Physics and also elevates their knowledge base to apply these foundations to the applied and advanced electives, specializations of their own choices. The students pursuing this course will develop in-depth understanding of various aspects of the core subjects of Physics by developing the deeper understanding level of different analogies, laws of the Nature through the subjects like classical mechanics, quantum mechanics, electrodynamics, statistical mechanics, condensed matter physics, atomic and molecular physics, nuclear physics, etc. The course also helps the students in enhancing their analytical skill through the embedded component of the problem solving skills, seminar activities and hands-on and minds-in activities of the course. The courses offered by the University are of student-centric nature and help them to understand the basic laws of nature and develop necessary skills to apply them to the advanced areas of studies.

There are **twenty core or mandatory courses (ten theory and ten lab courses)** meant to provide adequate knowledge on various aspects of physics discipline and to prepare the students for applying them for advanced courses. In addition, there will be skill based elective (specialization) as well as few open elective courses enabling cross-discipline movement to the students. The skill based elective courses are of more advanced nature and help the students to develop their skills in specific fields through more of the hands-on activities. The details of the courses and activities are as follows:

Outline of the M. Sc. Physics Program (Choice Based Credit System):

Students of M Sc Physics program are required to complete a total of 100 credits to acquire M. Sc. Physics degree. These required 100 credits constitute following components:

i. Core Courses: Every student completing post graduation in Physics from this university is required to have a comprehensive knowledge of few of the core or compulsory courses**, which includes classical mechanics, quantum mechanics, statistical mechanics, electrodynamics, nuclear physics, etc. and the related practical courses.** There shall be **ten** such theory papers (four each in first and second semesters and one each in third and fourth semester) and corresponding laboratory courses distributed over the span of four semesters. These courses are designed and upgraded looking at the recent developments in the subject and are inducted in the course so as to prepare the students to apply the acquired knowledge in various skill based advanced elective courses. This forms about **70%** of the total credits of M. Sc Physics Program.

ii. Elective: Students have freedom to earn remaining 30% credits by opting courses of their own choice. The available elective courses are of two different natures: **a. Discipline Specific Electives** or **Skill Enhancement courses** and **b. Open or Generic Electives**.

a. Skill Enhancement or Specialization Courses: These courses are aimed at providing advanced knowledge in specialized courses, where the students can employ the fundamental knowledge that they have acquired through the core courses. These courses are of advanced nature and enable the students to acquire highest level skills in the fields of **Astronomy and Astrophysics, Nanomaterials, Fiber optical communications and Advanced Electronics**. As these courses are primarily of **do-it-yourself** and **hands-on-training** type, therefore, students are expected to devote much of their time in laboratory activities in addition to the conventional classroom teaching. Therefore, roughly half of the time allocated to this course shall be utilized for the classroom teaching, imparting instructions, etc., while remaining half shall be utilized by the students in developing their skills through the hands-on exercises. The exercises to be undertaken for this purpose shall

be of different nature than that of their regular laboratory / practical courses. There shall be four such skill enhancement courses offered by the School each of four theory papers and related laboratory courses and will be spread over two semesters (Semester III and IV) and the students have freedom to choose any one of these special courses depending on their interest and inclination. The Skill Enhancement Courses presently offered by the School are listed below and the same shall be augmented on need basis. Students have freedom to choose either of the following combinations:

Combination	Course Name	Course Code (Semester III/IV)
Combination I	i. Astrophysics ii. Electornics	PHYET 302A/402A PHYET 303A/403A
Combination II	i. Materials Science ii. Fiber Optics and Lasers	PHYET 302B/402B PHYET 303B/403B

b. Open Elective Courses: Students have freedom to choose either one (of 04 credits) or two courses (each of 02 credits) of their interest and inclination from the pool of courses that are made available by the University for a particular semester. These courses are open for all the students from the campus Schools and are of specific or introductory or fundamental nature and are designed so as to provide extended scope to the students or enable them to expand their knowledgebase. M Sc Physics students shall also be required to choose **open electives courses of 10 credits offered by other schools on the campus of the University** i.e. these courses are of Inter-School nature. The students can also have a freedom to earn the required credits of open electives through the Transfer of Credits from the UGC recognized online courses like SWAYAM//MOOCS/NPTEL/Skill oriented courses or the courses offered by other institutes and universities. Attempts will also be made to offer elective courses of interdisciplinary nature from some other subjects, disciplines, or faculties; however, for the availability of such courses the students are required to consult their teachers.

The School of Physical Sciences also offers open elective courses, each of 04 credits, and shall be available for all the students from the School as well as from other schools on the University campus. However, the School students are not allowed to select the open elective course related to their Skill Enhancement (Specialization) at semester III and IV.

Semester III (PHYOT 304)	Semester IV (PHYOT 404)
1. Energy Studies	1. Plasma Physics
2. Wonders in the Sky	2. Nano Physics
3. Physics for Biologists and Chemists	3. Nuclear Physics and radiation
4. Communication Electronics	4. LIGO Science
5. Microprocessors and Microcontrollers	5. Optoelectronics

Guidelines to Choose Open Elective Course:

1. After taking admission to M Sc Physics S. Y. Program the students have to select open elective courses of their choice based on the eligibility of the concerned school that offers the open elective course
2. Students need to select only those open elective courses that are being made available by the schools for that academic years
3. Students need to apply for such a course to the Director of the concerned school where the chosen elective is being offered.
4. The concerned school shall publish the list of the admitted students for a particular open elective course after looking at the eligibility requirement
5. It is the responsibility of the student to check the admission to the particular open elective course
6. There will be a common time table for open electives in all the schools.
7. The assessment of open electives will be as per the guidelines of the CBCS scheme of the University and the host school that offers the particular course.
8. After evaluation the school shall communicate the assessment result of the open elective course to the Parent School of the concerned student
9. Any difficulty in operating the open elective course shall be resolved by the Directors of the respective schools in consultation with concerned authority if necessary.
10. The list of open elective shall be updated by the schools from time to time based on the reviews/demand/expertise/needs of the society.

Credit transfer from other Institutes:

Depending on the feasibility and availability, a maximum of four credits can be completed by the student in any of the national or reputed academic institutes/ organizations/ industries.

Audit Courses and Additional courses:

If the student wishes to complete more number of credits, he can opt additional courses up to a maximum of 10% of the total credits of the program depending on the interest and other feasibilities, however, such extra courses will be regarded as Audit or Additional courses. In general audit courses are of qualitative assessment without grades, while the additional credits are with grades. These additional credits shall be reflected on the Marks sheets / transcript of the student.

Objectives of M Sc Physics program:

1. To develop skills of critical thinking, hypothesis building and applying the scientific method of physics concepts, theoretical models and laboratory experiments
2. To develop problem solving skill for identifying and formulating problems independently and creatively employing the theoretical and/or experimental methods that he has acquired during the course
3. To train the students with a working knowledge of experimental/computational techniques and instrumentation required to work independently in research and industrial environments
4. To acquire advanced knowledge in specialized areas in physics that are in tune with the front-line research in physics
5. To prepare the students to successfully compete for current employment opportunities.

Program Outcome:

Students after completing their post graduation in Physics (M Sc Physics) will

1. be eligible to get employment as an assistant professor, teacher, etc. in private, semi-government, government in colleges and schools after fulfilling the requirements and can rise up to the top positions

2. pursue their higher studies in related fields including M Phil, Ph D in the national and international universities depending upon the eligibility conditions of the concerned universities
3. work as research fellow, scientist in research institutes and carry out research after qualifying the NET/SET/PET examinations
4. handle standard and advanced laboratory equipment, modern instrumentation and classical techniques to carry out experiments.
5. work as entrepreneurs

Duration:

The duration of M. Sc. Physics programme offered by the School is of 2 Years (4 semesters) with a total of 100 credits

Eligibility for Admissions to M Sc Physics Program:

- Any science graduate (B. Sc.) with Physics as main or one of the optional at B. Sc. from any recognized university is eligible to apply for admission to the M. Sc. Physics offered by this School. However, the candidate is required to have scored a minimum of 55% marks in B.Sc. program in the **first attempt** only and must have earned at least **24 credits in Physics at his graduation**.
- 4 Year B.E/B.Tech in Electronics /ECE/Electrical/EEE/Optics/Engineering Physics/Applied Physics/Mechanical/Instrumentation/Computer Science/Civil Engineering with a minimum percentage of 55 marks shall also be eligible for the admission to M Sc Physics program
- Admissions to this course shall be given strictly on the basis of the merit list depending on the score of the student in Physics at B. Sc level. All the candidates desiring admission to this program must register and submit their applications along with the attested copies of marks sheets of all the three years in the **first week of June every year.**

Examination/Evaluation Rules:

- For all the courses, 1 credit corresponds to 25 marks and requires 15 contact hours, which includes teaching, tutorials, remedial classes and seminars
- A minimum of 75 % attendance for theory and practical courses is a pre-requisite for appearing for examinations and qualifying a particular course

- The assessment of each of the theory course shall be done in two modes: i. Continuous Internal Assessment or **Mid Semester Assessment (MSA)**, and ii. **End Semester Assessment (ESA)**
- The Mid Semester Assessment shall be done throughout the semester in the form of mid-semester examinations, tests, home assignments, group discussions etc. Normally, there shall be two written tests, each of 20 marks and shall be of two hours duration, and one home assignment of 10 marks.
- The first test shall be conducted after five weeks of the commencement of the particular course and the other test shall be conducted after the 10 weeks.
- The **Semester End Assessment (ESA)** shall be usually conducted at the end of the respective semester in co-ordination with external examiners
- The MSA and ESA carries equal weightages i.e. **50:50** percent.
- **There shall be no internal or Mid Semester Assessment (MSA) for the laboratory courses. Assessment of the laboratory courses shall be done at the end of the respective semester by a panel of examiners appointed by the University**
- The minimum score required for passing a particular course is 40%
- There shall be independent passing for the MSA and ESA separately; otherwise the candidate shall be declared FAIL in that particular course. However, they shall be **Allowed-To-Keep-Term (ATKT)** at the most up to 25% and shall be eligible to get admission in to the third semester.
- A student passing end semester evaluation shall have to independently pass the internal assessment as per the schedule announced by the School. There shall be no provision of conducting the repeat examination either in MSA or ESA. If a student remains absent for the internal assessment he shall be declared FAIL for that particular course
- Failed candidates reappearing for the concerned SEA have to appear for the next regular examination conducted at the end of the following semester.
- Every students admitted to M Sc Physics third semester have to complete one project dissertation of 4 credits (100 marks) under the guidance of the faculty member as allocated him in the beginning of the third semester. The performance of the student in project work shall be assessed in both the modes i.e., the MSA of 50 marks and the ESA of 50 marks. ESA will be conducted by a panel of external examinations, where the candidate shall give a presentation on the work that he has conducted throughout the year.

- The **evaluation and grading** of the courses shall be as per the guidelines of UGC, New Delhi and the modified **Grades and Grade Points** (As per UGC) shall be as follows:

UGC Letter Grade	UGC Grade Points	UGC Marks obtained
O : Outstanding	10	>80
A+: Excellent	9	70-79
A: Very Good	8	60-69
B+: Good	7	55-59
B: Above Average	6	50-54
C: Average	5	45-49
P: Pass	4	40-44
F: Fail	0	<40
Ab: Absent	0	---

Salient Features of the course:

1. Masters Program in Physics (M. Sc. Physics) shall be of total 100 credits; distributed over four semesters
2. Each of the credit is equivalent to 15 clock hours and is spread over one complete semester.
3. Out of 100, 62 credits form the mandatory core component of the course
4. The students have freedom to select any of the 28 credits form the skill enhancement elective (specialization) courses of their choice offered by the School
5. They also have a choice to select any of the 10 credits course either from the School (intra) or from other Schools on the campus (inter) that are made available in the fourth semester of their post graduation.
6. To inculcate research aptitude among the students, they are also required to complete one project dissertation of 04 credits during semester III and IV, whose assessment will be done at the end of the Semester IV.
7. With an objective to develop soft skill among the students, they are required to deliver one seminar or colloquia in each semester, which shall be assessed by the teacher. The topic for such seminars shall be other than their regular course and should be of advanced nature.

8. The candidate shall be declared as **Failed** if he/she does not clear all the credits within the stipulated period. However, such students will be given four attempts to clear the courses, failing to which shall be required to seek fresh admission following the admission rules prevailing at that time.

M. Sc. Physics syllabus given in this document was prepared by various subcommittees constituted in the meeting of the School of Physical Sciences and was finalized after inviting comments, suggestions from experts in the field in different universities, institutes, industries and alumni of the School. The same has been approved by the regular Board of Studies in Physics, the Faculty of Science & Technology and the Academic Council before implementation, and shall be implemented from the academic year 2020-2021.

(Prof. M. K. Patil)
Professor and Director,
School of Physical Sciences
Chairman
Board of Studies in Physics

Course Structure and Marking Scheme of M. Sc. Physics

M. Sc. First Year (Semester I) Physics

Course Code	Name of the Course	Credits	Contact (instruction) hours		Assessment pattern (marking scheme)		
			Lect. / week (L+T+R)	Total Hrs	MSA (T1+T2+ HA)	SEA	Total Marks
PHYCT 101	Mathematical Methods in Physics	04	05	60	50	50	100
PHYCT 102	Numerical Techniques in Physics	04	05	60	50	50	100
PHYCT 103	Classical Mechanics	04	05	60	50	50	100
PHYCT 104	Electronic Devices and Applications	04	05	60	50	50	100
PHYCL 111	Computer Programming Lab	02	02	30	--	50	50
PHYCL 112	Numerical Techniques Lab	02	02	30	--	50	50
PHYCL 113	General Electronics Lab	02	02	30	--	50	50
PHYCL 114	Digital Electronics Lab	02	02	30	--	50	50
	Total Credits / Marks	24 credits	---	---	---	---	600

M. Sc. First Year (Semester II) Physics

Course Code	Name of the Course	Credits	Contact (instruction) hours		Assessment pattern (marking scheme)		
			Lect. / week (L+T+R)	Total Hrs	MSA (T1+T2+ HA)	SEA	Total Marks
PHYCT 201	Condensed Matter Physics	04	05	60	50	50	100
PHYCT 202	Atomic and Molecular Physics	04	05	60	50	50	100
PHYCT 203	Statistical Mechanics	04	05	60	50	50	100
PHYCT 204	Quantum Mechanics	04	05	60	50	50	100
PHYOT 205	Communication Skill OR Teaching Competency	02	02	30	25	25	50
PHYCL 211	Solid State Physics Lab	02	02	30	--	50	50
PHYCL 212	Semiconductor Physics Lab	02	02	30	--	50	50
PHYCL 213	General Physics Lab	02	02	30	--	50	50
PHYCL 214	Spectroscopy Lab	02	02	30	--	50	50
	Total Credits / Marks	26 credits	---	---	---	---	650

M. Sc. Second Year (Semester III) Physics

Course Code	Name of the Course	Credits	Contact (instruction) hours		Assessment pattern (marking scheme)		
			Lect. / week (L+T+R)	Total Hrs	MSA (T1+T2+ HA)	SEA	Total Marks
PHYCT 301	Electrodynamics	04	05	60	50	50	100
PHYET 302	Skill Enhancement Course – I	04	05	60	50	50	100
PHYET 303	Skill Enhancement Course – II	04	05	60	50	50	100
PHYOT 304	Open Elective – I (from other schools)	04	05	60	50	50	100
PHYEL 311	Skill Enhancement Lab – Ia	02	02	30	--	50	50
PHYEL 312	Skill Enhancement Lab – Ib	02	02	30	--	50	50
PHYEL 313	Skill Enhancement Lab – IIa	02	02	30	--	50	50
PHYEL 314	Skill Enhancement Lab – IIb	02	02	30	--	50	50
	Total Credits / Marks	24 credits	---	---	---	---	600

M. Sc. Second Year (Semester IV) Physics

Course Code	Name of the Course	Credits	Contact (instruction) hours		Assessment pattern (marking scheme)		
			Lect. / week (L+T+R)	Total Hrs	MSA (T1+T2+ HA)	ESA	Total Marks
PHYCT 401	Nuclear Physics	04	05	60	50	50	100
PHYET 402	Skill Enhancement Course – III	04	05	60	50	50	100
PHYET 403	Skill Enhancement Course – IV	04	05	60	50	50	100
PHYOT 404	Open Elective – II (from other schools)	04	05	60	50	50	100
PHYCL 411	Nuclear Physics Lab	02	02	30	--	50	50
PHYEL 412	Skill Enhancement Lab – III	02	02	30	--	50	50
PHYEL 413	Skill Enhancement Lab – IV	02	02	30	--	50	50
PHYCL 415	Research Oriented Project	04	04	60	50	50	100
	Total Credits / Marks	26 credits	---	---	---	---	650

- **There shall be no internal or Mid Semester Assessment (MSA) for the laboratory courses. Assessment of the laboratory courses shall be done at the end of the respective semester by a panel of examiners appointed by the University.**

PHYCT 301 – Electrodynamics (Core-17)

***Credits:* 04**	***Contact Hours*: 60** *(L+T+R)*	***Total Marks:* 100** **[MSA: 50** *(T1+T2+HA=20+20+10)*; **ESA=*50*]**

Learning Objectives: *Objective of this course is to introduce the students to the concepts of electromagnetic field theory, interaction of EM waves matter, propagation in continuous media, reflection-refraction of EM waves at the boundaries separating two media and its application in communication theory. This paper also introduces the students to the sources of EM waves and antenna theory. Relativistic EM enables them to understand the effect of the radiation when sources are moving with relativistic velocities. Prerequisite for this course is that the students must have the idea of electrostatics, magnetostatics and electromagnetic induction phenomenon.*

Learning Outcome: *Upon successful completion of this course students will be able to apply the knowledge of Maxwell's equations to a variety of problems including various types of charge distributions including time-dependent processes, tackle the problems related to the propagation and scattering of EM waves in a variety of media, understand how to design EM sources of different powers, and will also be able to have a good understanding of the relativistic electrodynamics.*

Module-I: Maxwell equations and Electromagnetic waves (15 Hrs)

Maxwell's equations and their physical significance. Equation of continuity & relaxation time, Vector and scalar potentials, Lorentz and Coulomb gauge, gauge transformation, electromagnetic energy and Poynting's theorem, electromagnetic wave equations in free space, their plane wave solutions, waves in conducting medium: skin effect and skin depth, waves in ionized medium (ionospheric propagation), polarization of EM waves. Concept of radiation pressure

Module-II: Electromagnetic waves in bounded media (15 Hrs)

Reflection and refraction of plane electromagnetic waves at a plane interface: normal incidence, oblique incidence, Fressnel's equations, Brewster's angle. Total internal reflection. Reflection and refraction from metallic surfaces, Electromagnetic wave propagation between two parallel conducting plates, waves in hollow conductors, Rectangular wave guides - TE and TM modes.

Module-III: Radiations from moving charges (15 Hrs)

Concept of retarded potential, The Lienard-Wiechert potentials, Field produced by moving charges, radiation from a linearly accelerated charged particle at low velocity, radiation from accelerated charged particles at low velocities in circular orbits-Larmor formula, radiation from accelerated charged particles at relativistic velocities in circular orbits-relativistic generalization of Larmor formula Multipole expansion of EM field, Electric dipole radiation, field due to oscillating electric dipole, magnetic dipole radiations, electric quadrupole radiation, fields due to linear centre-fed half wave and full wave antenna, array of antennae

Module-IV: Covariance and Relativistic Electrodynamics (15 Hrs)

Basic kinematical results of special relativity (length contraction, time dilation, addition of velocities, charge invariance, field transformation, etc), relativistic momentum and energy of a particle, 4-vectors in electrodynamics, 4-potential and 4-current, electromagnetic field tensor, Lorentz force and equation of motion of a charged particle in an electromagnetic field, Covariance of Maxwell's equations, transformation of EM fields and field tensor. Electromagnetic wave equation and plane wave solution in 4-vector form.

Reference Books:

1. Classical Electrodynamics - J.D.Jackson (John Wiley & Sons)
2. Introduction to Electrodynamics, (3rd Edition) by David J.Griffith. (Prentice-Hall, India)
3. Classical Electromagnetic Radiation - J.B.Marion (Academic Press)
4. The Classical theory of Fields - Landau & Lifshitz (Pergman Press)
5. Electrodynamics of continuous media - Landau & Lifshitz (Butter Worth)
6. Electricity and Magnetism - David J.Griffiths (PHI)
7. Electricity and Magnetism - Panofsky and Philips
8. Electromagnetic waves and fields - R.N.Singh (Tata McGraw Hill)
9. Electromagnetic Waves and Radiation system - Jordan and Balman (PHI)
10. Electromagnetic Fields and waves -Paul Lorrain and Dale Corson (CBSPub)
11. Electromagnetics - B.B.Laud (New Age Intl. Pub.)
12. Introduction to Electrodynamics- A. Z. Capri and P. V. Panat (Narosa)

PHYET 302A – Skill Enhancement Course-I : Astrophysics- I

***Credits:* 04**	***Contact Hours*: 60** *(L+T+R)*	***Total Marks:* 100** **[MSA: 50** *(T1+T2+HA=20+20+10)*; **ESA=50]**

Learning Objectives: *Astrophysics course of this university is designed in such a way that it leads the students to build their foundation to understand the excitements in the deepest quests of the physical universe and acts as the capstone of M. Sc. Physics. The course will introduce the learners to the astronomical observational techniques, including photometry, imaging, spectroscopy, and interferometry; develop skill of error analysis, problem solving in analytic, computational, and telescope plus detector systems; and effective scientific writing through project dissertation reports. The science of astrophysical bodies involves the study of matter and radiation in the universe with an objective to understand it through the laws of physics. Astronomical phenomena encompasses extreme range of physical conditions, from super-fluid neutrons in neutron stars, high-temperature nuclear reactions in supernovae, and strong gravitational fields near black holes, to the unique state of the universe during its earliest phases. Therefore, it is not an exaggeration to say that, "**Astronomy is celestial art gallery and infinite Physical and Chemical laboratory.***

Theoretical attempts to describe these and more familiar phenomena (such as stars and galaxies) enable the students to achieve important level of understanding in several cases and enable them to stretch the knowledge of contemporary physics to its limits in attempting to understand physical conditions, which otherwise cannot be reproduced in terrestrial laboratories. Astrophysics applies the knowledge of Classical Mechanics, Quantum Mechanics, Nuclear physics, Statistical Mechanics, Electrodynamics, Spectroscopy, Mathematical Physics, Modern Electronics and even Chemistry also. Therefore, the pre-requisite of the course is that the students who select this course as their skill enhancement elective course must have adequate knowledge of all the core courses in Physics.

*The concentration in Astrophysics introduces students to a broad range of phenomena through a program of both observational and theoretical courses and represents a departure from conventional courses by encouraging them to develop, debug, research, design, and explore all aspects necessary for astronomical observations. This course is mainly designed with "**hands-on**" strategy and will utilize a great deal of the understanding developed M Sc. Physics First Year core course. The students will learn how to use, handle small optical telescopes, the computer-operated 16" ACF MEADE telescope, CCD imagers, solid state photometers, and the small radio telescope. Operating the rooftop telescope for conducting observational exercises of astronomical bodies is an essential component of the course. On an average observing time load during the year would be about 30-40 hours per student. Students doing their observing projects / dissertations are required to use these facilities over the clear nights throughout the year in order to complete their projects.*

Learning Outcomes: *The students after completing this course will become conversant with basic error analysis and propagation; conduct real, quantitative telescopic observations and experiments; write comprehensive lab reports in good scientific writing style; conduct quantitative image analyses; perform quantitative photometry; perform quantitative spectroscopy; learn about the signal-to-noise ratio and its relation to the astronomical observations; expert in analyzing data with regard to convolution, de-convolution, and Fourier analysis and perform function fitting to the real data; expert in optics concepts and optical designs and data mining. This course provides good base for the students to further their higher studies for M.Phil and Ph.D. in the field of Astronomy & Astrophysics. After successful completion of the Masters' degree with good scores, the students have opportunities*

to join leading research institutes in the field as research scholars leading to the Ph.D. and also to become astrophysicists, scientists or research officers in the field of space research in various institutes within India and in foreign countries. They can also join teaching profession in universities, colleges and institutes after clearing NET exam conducted by CSIR, New Delhi.

Seminar: *Oral presentation by the student is an important aspect of astronomy course. The students are required to give at least two half-hour duration presentations on the topic of their interest before the class in each semester. However, the topic selected for the presentation should be other than those discussed in the class. Power point presentations are preferred for the seminar and should be prepared with good quality and proper attribution.*

Module-I: Observational Techniques (15 Hrs)

Brief history of astronomy (geocentric universe, heliocentric universe), co-ordinate systems (celestial sphere, horizon, equatorial, ecliptic co-ordinate systems), various windows in astronomy (multi-wavelength astronomy), 21-cm line and its importance in astronomy.

Astronomical distances: astronomical unit (AU), light year, parsec, distance measurement in astronomy-stellar parallax and other methods.

Telescopes: Basic optics, Optical telescopes- reflecting and refracting type, various focusing methods, telescope mountings, new technology telescopes, HST.

Radio Telescopes and interferometers, very large array (VLA), concept of Very long baseline interferometry (VLBI).

Infrared, Ultraviolet and X-ray astronomy (elementary idea), Chandra Telescope, ASTROSAT.

Detectors: Photographic plates, photometers, CCDs. Filter systems, NICMOS camera and X-ray detector.

Module-II: Radiative Processes (15 Hrs)

Black body radiation - specific intensity, flux density and luminosity, Planck's law, Wien's displacement law and Sefan's law.

Description of the radiation field, Opacities, Basics of radiative transfer - emission coefficient, absorption coefficient, source function, formation and structure of spectral lines.

Radiative processes: Synchrotron emission-for a single electron and an ensemble of electrons, Compton scattering, bremsstrahlung and thermal bremsstrahlung.

Module-III: Stellar Astrophysics (15 Hrs)

Stellar brightness - luminosity, stellar magnitudes, distance modulus, colour index, and stellar temperature.

Stellar spectra – spectral classification of stars, luminosity classification of stars, the Hertzsprung-Russell (H-R) diagram, Observational data on stars (HR diagram), Stellar population- Population I and II, Star clusters-open clusters, globular clusters.

The Sun: solar interior- energy transport, magnetic activity in the Sun, Sunspots and sunspot cycle, solar limb darkening, solar neutrino puzzle.

Module-IV: Stellar Structure and Evolution (15 Hrs)

Star formation: Interstellar gas and dust, the Jean's criteria, formation of protostar, pre-main sequence evolution of stars

Basic equations of stellar structure, Hydrostatic equilibrium, pressure equation of state, Stellar energy sources and nucleo-synthesis (p-p chain reaction, CNO cycle, triple alpha reaction, r & s processes), energy transport in stars

Stellar Evolution: Post-Main sequence Evolution in the main sequence, late stages of stellar evolution-Giant, Super giant phase.

End state of stars: White dwarfs, degenerate matter, Chandrasekhar limit, mass-radius relation for a white dwarf star; Neutron stars- its upper mass limits, pulsars; Black Holes.

Introduction to Supernova & supernova remnants, neutron stars, pulsars and magnetars.

Tutorials - will involve problem solving on the topics of the course.

Reference Books:

1. Modern Astrophysics – B.W. Carroll and D.A. Ostlie, 1996, Addison-Wesley Publishing Co., Inc.
2. The Physical Universe: An Introduction to Astronomy – Frank H. Shu, 1982, University Science Books, Sausalito, California.
3. Theoretical Astrophysics, Vol I: Astrophysical Processes, T. Padmanabhan, Cambridge University Press.
4. Fundamental Astronomy – ed. H. Karttunen, P. Kroger, H. Oja et al., 1987, Springer-Verlag, Berlin.
5. Introductory Astronomy & Astrophysics, M. Zeilik and S. A. Gregory, 4th edition, Saunders College Publishing.
6. The New Cosmos, 4th edition - A. Unsold and B. Baschek, 1991, Springer-Verlag, Berlin.
7. Astrophysics: Stars and Galaxies – K.D. Abhyankar, 1992, Tata McGraw Hill Publishing Co., New Delhi.
8. Cosmology and Astrophysics through Problems – T. Padmanabhan (Cambridge Univ Press)
9. Text Book of Astronomy and Astrophysics with Elements of Cosmology – V.B.Bhatia, 2001, Narosa Publishing House, New Delhi.

PHYET 302B – Skill Enhancement Course I: Materials Science- I

Credits: **04**	*Contact Hours*: **60** *(L+T+R)*	*Total Marks:* **100** **[MSA: 50** *(T1+T2+HA=20+20+10)*; **ESA=50]**

Learning Objective:

1. *The course is intended to make the students to get familiar with basic concepts of phase diagram especially binary phase diagrams and microstructure of different materials. It is to be noted that microstructure plays a vital role in deciding the properties of the materials. Thus, it is importance of phase diagram and microstructure evolution.*
2. *The objective of the course is to provide a technological background of production of vacuum, to understand the operation of mechanical, diffusion, and ion pump systems, to get acquainted with thin film technology*
3. *3.The aim is to impart knowledge of mass transfer operations like diffusion, absorption*
4. *To shed light on applications of crystals to various industries, various techniques for crystallization, basic steps of crystallization*

Learning Outcome:

1. *Students will be able to know that microstructure decides the properties of the materials and will be able to relate the phase diagram information for micro structural evolution*
2. *Students will be able to describe its importance of vacuum in various industries and research field and will be able to apply important laws of physics for working of vacuum system*
3. *Students will be able to understand the fundamental equilibrium and transport properties in adsorption and diffusion process*
4. *Students will be able to grow crystals, differentiate various growth techniques, to understand importance of growth processes*

Module-I: Phase Diagram (15 Hrs)

Basic concepts, solubility limit, phases, phase equilibrium, Gibb's phase rule, unary diagram, effect of pressure on phase diagram, binary isomorphous phase diagrams; Copper-Nickel system, Microstructure formation under equilibrium solidification & non equilibrium solidification of an alloy, coring, Binary eutectic systems; Lead–Tin system, Silver-Copper system and Fe-Fe3C system; Solidification of eutectic, hypo-eutectic, and hyper-eutectic alloys and microstructure formation under equilibrium cooling, salient features, invariant reactions, Lever rule, determination of phases & phase fractions

Module-II: Mass Transport Phenomenon (15 Hrs)

Diffusion

Introduction, diffusion mechanisms, steady state diffusion, non-steady state diffusion, Fick's first and second law, factors influencing diffusion, other diffusion paths, diffusivity in gas mixtures, liquid mixtures and solids, numerical problems

Adsorption

Introduction, Physical & chemical adsorption, adsorption materials, nonporous & porous adsorbents, factors affecting adsorption, characteristics of adsorption, types of adsorption, adsorption isotherms, classification, Freundlich's and Langmuir adsorption isotherms, applications of adsorption

Module-III: Vacuum Physics and Thin Film Technologies (15 Hrs)

Introduction to vacuum, types of flow, pumping speed, throughput, construction and working principle of Pumps, rotary pump, oil diffusion pump, adsorption pump, sputter ion pump, Turbo molecular pump, construction and working principle of gauges, thermocouple gauge, pirani gauge, ionization gauge, penning gauge

Thin Films

Physical Vapour Deposition, Chemical Vapour Deposition, Sputtering, Spray pyrolysis, Dip coating and Spin coating, Electron –beam deposition, Laser Ablation.

Module-IV: Crystal Growth (15 Hrs)

Introduction, Steps in crystallization, super saturation, nucleation, crystal growth, crystal growth techniques; solution growth technique, critical size, Gel growth technique, Flux growth, Hydrothermal technique, melt growth; czochrolski crystal pulling method, zone melting, Verneuil Flame Fusion Method, Vapour phase epitaxy

Reference Books:

1. Materials Science and Engineering An Introduction, William Callister,Jr., (Wiley India)
2. Vacuum Physics and Techniques, Delcher
3. Handbook of Vacuum Science and Technology, Hoffman
4. Vacuum Science and Technology, Rao, Ghosh, K.L.Chopra, Allied Publishers Ltd.
5. Thin Film Process: J. L. Vossen and Kern, (Academic Press) 5. Thin Film Phenomena: K. L. Chopra, (Mc Graw Hill)
6. Crystallization by Mullin
7. Crystal Growth, Santhana Raghavan & Ramaswamy, KRU Publications
8. Materials Science and Engineering , V.Raghavan, Prentice-Hall of India PVT

PHYET 303A – Skill Enhancement Course II
Electronics-I: Microwave Devices and Transmission Lines

Credits: **04**	*Contact Hours*: **60** *(L+T+R)*	*Total Marks:* **100** **[MSA: 50** (*T1+T2+HA=20+20+10)*; **ESA=50]**

Learning Objectives: *The paper on Microwave Devices and Transmission Lines is well designed and concentrates on Microwave Electronics and Measurements. It has covered basic as well as applied aspects of microwaves, covering microwave sources, properties, applications. This paper gives exposure to the electric field and magnetic field and combination of these two fields forming EM waves. Microwave waveguide components and microwave devices such as GaAs diode, READ diode, IMPATT, BARITT diodes are explained along with PIN and Schottky diodes.*

Learning Outcomes: *Completion of this course enables the students to understand the basic EM theory and microwave devices. The microwave components have been reinvented in the form of strip line and microstrip form and this MIC technology has drastically reduced the size as well as cost. Moreover, the method of measurements is also included in this paper. This specific study enables the student to work in R & D organizations for further studies and jobs in private/Govt. Sectors.*

Module-I: Microwave Fundamentals and Transmission Lines (15 Hrs)

Microwave frequency and band designation, Fundamental of transmission lines, Different types of transmission lines; Definition of characteristics impedance, Propagation constant and Losses in transmission lines. Microwave transmission line analysis, Reflection coefficient ,Standing waves, sanding wave ratio(SWR),VSWR ,Quarter and Half wavelength lines, Reactance properties of transmission lines, Fundamental of the Smith charts and its applications. Microwave wave guide.

Module-II: Microwave active devices (15 Hrs)

Microwave vacuum tube devices:

Klystron, velocity modulation, bunching process, reflex klystron, efficiency, electronic admittance. Magnetron and Traveling wave tubes: Principle of operation of magnetron, microwave characteristics. Helix TWT's, amplification process, wave modes and gain considerations.

Microwave solid state devices: Microwave transistor, MOSFETs, transferred electron devices, Gunn effect, principle of operation, modes of operation. LSA diode, Read diode, IMPATT and TRAPATT diodes, parametric devices, non-liner reactances, parametric up-down converters and applications.

Module-III: Microwave passive devices (15 Hrs)

Waveguide components and networks: Cavity resonators, Q of cavity resonator, cavities, slow wave structure, microwave hybrid circuits and S parameters, waveguide Tees, directional couplers, phase shifters, attenuators and slide screw tuner. Microwave bend, Match Load, Waveguide Termination, Ferrite Materials, Isolator, Circulator Phase Shifter.

Module-IV: Microwave integrated circuits and Antennas (15 Hrs)

STRIP LINES : Microstrip lines (Characteristics impedance of microstrip line, Effective dielectric constant, Transformation of rectangular conductor into equivalent circular conductor, characteristic impedance equation, Losses in microstrip lines, Quality factor Q of microstrip lines).Parallel strip lines

(Distributed parameters, characteristic impedance, Attenuation losses), coplanner strip lines, shielded strip lines.

MMIC: Monolithic microwave integrated circuits (Materials, substrate materials, conductor materials, Dielectric materials, Resistive materials), MMIC Fabrication techniques, Fabrication examples, Thin Film Formation (Planner resistor Film, Planer inductor Film, Planer capacitor Film), Hybrid integrated circuit fabrication.
Antennas: Basic antenna parameters: Radiation pattern, radiation intensity, directivity, radiation resistance, efficiency and gain. Effective aperture antennas, effective height, dipole antenna, helical antenna.

Reference Books:

1. Microwave Radar Engineering- *by M. Kulkarni, Umesh Publicatios, New Delhi.*
2. Microwave Devices and Applications by Dinesh C Dube Narosa Publishing House New Delhi
3. Understanding Microwaves-*by Allan W. Scott, A. John Wiley & Sam Ins. Publications*
4. The Microwave Engineering Handbook Vol. I, II and III *–by L. Smith & Michel Henri Carpentire, Springer Industrial edition.*
5. Microwave Devices and circuits- by *Samuley Y. Liao, Prentice Hall of Gredia Private Limited, New Delhi.*
6. Microwave Circuits and Passive devices-*by M.L. Sisodia &G.S. Raghuvanshi, Wiley Eastern Limited, New Delhi.*
7. Microwave Engineering- *by Sanjeev Gupta, Khanna Publication, New Delhi.*
8. Electronics Communication System *–by Kennedy George, McGraw Hill book Company*
9. Communication Components & Circuits-*by Edgar Hund, Mc-Graw Hill*

PHYET 303B – Skill Enhancement Course II

Fiber Optics and Lasers- I

***Credits:* 04**	***Contact Hours*: 60** *(L+T+R)*	***Total Marks:* 100** **[MSA: 50** *(T1+T2+HA=20+20+10)*; **ESA=*50*]**

Learning Objective: *Use of the optical fibers in the communication system has revolutionized the global telecommunication scenario. With its very high range data handling capability and high rate capacity, optical fiber systems link globe with end users. They have enabled the internet and changed our society. This course is to introduce the student to the subject of lasers and fiber optics. This course is designed to cover the operation and characteristics of the lasers along with fiber optics, which is playing a vital role in current e-communication technology.*

Learning outcome: *Upon successful completion of our fiber optic and laser course, the student will build his/her knowledge of different types of lasers used for various applications from home to industry and signal transport through fiber optics for e-communication applications.*

Module-I: Optical Fiber Waveguides (15 Hrs)

- Fundamentals of optics: Ray Theory, Total Internal reflection, Acceptance angle, Numerical aperture, Skew ray
- Electromagnetic mode theory: Electromagnetic waves, modes in planer waveguides, phase and group velocity.
- Phase shift with TIR and Evanescent field,
- Goose-Effective refractive index.
- Basics of optical fiber and their types, Optical Fiber Structures, wave guiding
- Dispersion and losses in optical Fiber
- Modes in cylindrical fibers and coupling
- Cut-off wavelength, mode field diameter and spot size

Module-II: Optical Fibers: Synthesis and Fabrication (15 Hrs)

- Preparation of optical fiber
- Liquid phase (melting) technique and fiber drawing
- Vapour phase deposition technique
- Outside vapour phase oxidation process
- Vapour deposition
- Modified chemical vapour deposition
- Plasma activated chemical vapour deposition

Module-III: Lasers and Types of Lasers (15 Hrs)

- **Basics of Lasers:**
    - Properties of Lasers: directionality, intensity, mono-chromaticity, coherence
    - Einstein's quantum theory of radiation, Einstein's coefficients, momentum transfer, lifetime, possibility of amplification.
    - Population inversion and optical pumping: 2 and 3- level systems

- Pumping sources: Electrical (Glow discharge) and Optical (Flash and Arc lamps)
- Resonators
- Quality factor Q
- Mode locking

- **Types of Lasers:**
  - Gas Lasers: He-Ne lasers, N_2 lasers, Excimer lasers
  - Solid State Laser: Neodymium laser, Ruby laser

Module-IV: Applications of Lasers (15 Hrs)

- Optical Communications,
- Ranging and Navigation,
- Meteorology,
- Machining,
- Surgery
- Medicine
- Chemical and Physical processes

Reference Books:

1. Lasers & Nonliner Optics, B B Laud, Wiley Eastern
2. Introduction to Lasers, Koichi Shimoda, Springer Verlag
3. Optics and Lasers, M Young, springer Verlag
4. Masers & Lasers, J S Thorp, Mcmilan
5. Laser Electronics, Verdeyen Prentice Hall
6. Optical Fiber Communication: Principles & Practices, John M Senior

PHYOT 304 – Open Elective-II

(From other school)

Credits: **04**	***Contact Hours*****: 60** *(L+T+R)*	***Total Marks:*** **100** **[MSA: 50** (*T1+T2+HA=20+20+10)*; **ESA=*50*]**

PHYEL 311A – Skill Enhancement Laboratory-I - Astrophysics Laboratory - I

***Credits:* 02**	***Contact Hours*: 30** *(Hands-on)*	***Total Marks:* 50** **[ESA=*50*]**

Learning Objectives: *Objective of this Laboratory course is to introduce the students to the practical applications of the Skill Enhancement Course (PHYET 302A) that the students have studied in Semester III. After completing this course, students will be able to understand the characteristics and handling of the instruments, understand the properties of the Sun and other stars in the Milky Way. Each student appearing for semester end examination must produce a journal showing that he has completed* ***at least 6*** *experiments of this paper during the year.*

Astrophysics Laboratory -I:

1. Studying Solar Limb darkening
2. Estimating color of a star and hence effective surface temperature by differential photometry
3. Characterizing a CCD camera for gain, read-noise, linearity and flat-field
4. Broad band imaging of celestial objects using CCD camera
5. CCD data reduction
6. Classification of galaxies in the Virgo cluster
7. Verifying Hubble's law of expanding universe and hence estimating age of the universe (CLEA)
8. Estimating distance of the Galactic nova
9. Gravitational bending of the starlight
10. Acquiring the spectra of stars, classifying them and hence identifying chemical elements in the stars.(CLEA)
11. Estimating mass of the Andromeda galaxy by studying its dynamics
12. Photometric study of variable stars (Light curve)

PHYEL 311B – Skill Enhancement Laboratory-I - Material Science Laboratory - I

***Credits:* 02**	***Contact Hours*: 30** *(Hands-on)*	***Total Marks:* 50** **[ESA=*50*]**

Material Science Laboratory Experiments:

1. Preparation of CdS thin film by CBD technique and to determine band gap of CdS .
2. To deposit ZnS thin film on glass substrate by CBD technique at RT and to determine band gap using UV-VIS technique.
3. To deposit thick film of ZnO by sol gel technique.
4. To deposit thin films by spray pyrolysis technique.
5. To deposit copper thin film by electroplating.
6. To deposit Cadmium telluride (CdTe) films by successive ionic layer adsorption and reaction (SILAR) method
7. To grow single crystal (sodium oxalate) using silica hydrogel and to characterize it by TGA.

PHYEL 312A – Skill Enhancement Laboratory-II - Astrophysics Laboratory - II

***Credits:* 02**	***Contact Hours*: 30** *(Hands-on)*	***Total Marks:* 50** **[ESA=*50*]**

Learning Objectives: *Objective of this Laboratory course is to introduce the students to the practical applications of the Skill Enhancement Course (PHYET 302A) that the students have studied in Semester III. After completing this course students will be able to understand the characteristics and handling of the instruments, understand the properties of the Sun and other stars in the Milky Way. Each student appearing for semester end examination must produce a journal showing that he has completed* ***at least 6*** *experiments of this paper during the year.*

Astrophysics Laboratory – II:

1. To estimate the relative magnitudes of a group of stars by a CCD camera
2. To study the atmospheric extinction for different colors
3. Differential photometry of a program star w.r.t. a standard star
4. To study the effective temperature of stars by B. V. photometry
5. To estimate the night sky brightness with a photometer
6. To estimate the distance to the moon by parallax method
7. Calibration of a 1420 MHz radio reciever and spectrometer
8. Detection of 21-cm line of neutral hydrogen from our galaxy
9. To estimate the distance to a Cepheid variable
10. To study the variability of delta Scuti type stars
11. To study the variability of RS CVn binaries
12. To measure the polarization of day/moon light
13. Surface photometry of elliptical galaxy
14. CCD imaging photometry of star clusters

PHYEL 313B – Skill Enhancement Laboratory-II - Material Science Lab - II

Credits: **02**	*Contact Hours*: **30** *(Hands-on)*	*Total Marks:* **50** **[ESA=*50*]**

Material Science Laboratory Experiments:

1. To study thermal analysis of a Pb-Sn alloy.
2. To determine the magnetic susceptibility arising due to water in the solution of (MnCl2).
3. To determine the magnetic susceptibility of a solid material.
4. To identify unknown element from the X-ray diffraction pattern
5. To synthesize nickel ferrite nano-particles.
6. To study the photo catalytic properties of a given catalyst.
7. To prepare /synthesize Polyaniline.
8. To deposit polymer film on glass substrate by casting method and its characterization by FTIR technique.

PHYEL 313A – Skill Enhancement Laboratory-I - Electronics Laboratory - I

***Credits:* 02**	***Contact Hours*: 30** *(Hands-on)*	***Total Marks:* 50** **[ESA=*50*]**

Microwave Electronics Laboratory Experiments:

1. To study characteristics of Gunn diode using X-band microwave setup
2. To study the characteristics of Reflex Klystron tube using X-band
3. To determine the frequency & wavelength in a rectangular wave guide Working on TE10 mode.
4. To determine the Voltage Standing wave Ration (VSWR) and Reflection coefficient of given load using X-band microwave setup
5. To study the radiation pattern and Gain of Waveguide Horn Antenna using X-band Microwave setup

PHYEL 313B – Skill Enhancement Laboratory-I - Fiber Optics & Lasers Lab - I

Credits: **02**	*Contact Hours*: **30** *(Hands-on)*	*Total Marks:* **50** **[ESA=*50*]**

Fiber Optics and Lasers Laboratory Experiments

1. To the study of fibre coupling misalignment (lateral displacement, end separation, angular misalignment).
2. To determine the diameter of wire from the study of Fraunhofer diffraction pattern.
3. To determine the wavelength of laser beam with the help of Fraunhofer diffraction pattern obtained by wire.
4. To determine the microspacing of given sample (groove) using laser diffraction.
5. To determine the wavelength of He-Ne laser beam by using groove object.
6. To determine the Fraunhoffer diffraction pattern of Circular Apperture.

PHYEL 314A – Skill Enhancement Laboratory-II - Electronics Laboratory - II

Credits: **02**	*Contact Hours*: **30** *(Hands-on)*	*Total Marks:* **50** **[ESA=*50*]**

Microwave Electronics Laboratory Experiments:

1. To study function of Microwave Directional coupler and compute (i) Coupling Factor and (ii) Directivity
2. To study Properties of Microwave E-Plane Tee.
3. To study Properties of Microwave Magic Tee using microwave setup.
4. To study Faraday rotation by applying different magnetic field across microwave propagating in a rectangular waveguide using X-band.
5. To study properties of Microwave H-plane Tee

PHYEL 314B – Skill Enhancement Laboratory-II - Fiber Optics & Lasers Lab - II

Credits: **02**	*Contact Hours*: **30** *(Hands-on)*	*Total Marks:* **50** **[ESA=*50*]**

Fiber Optics and Lasers Laboratory Experiments

1. To determine the diameter of the Circular Aperture with the help of Fraunhofer diffraction pattern.
2. To determine the power loss in optical fibre by micro bend pressure sensor and calculate its pitch.
3. To determine the Numerical Aperture of a given multi mode fibre using far field scanning measurement.
4. To determine the Refractive Index of the given liquid using laser beam.
5. To determine the Refractive Index profile of multi mode fibre by transmitted near field scanning technique.
6. To determine the MFD of s fundamental mode in a single mode fibre by measurement of far field

PHYCT 401 – Nuclear and Particle Physics (Core-18)

***Credits:* 04**	***Contact Hours*: 60** *(L+T+R)*	***Total Marks:* 100** **[MSA: 50** *(T1+T2+HA=20+20+10)*; **ESA=*50*]**

Learning Objective: *This paper is about the Physics of Nucleus. It helps to introduce students about the fundamental principles of nucleus and understanding at deeper level concepts governing nuclear and particle physics and new phenomenon at each level. It gives information about elementary particles*

Learning Outcome: *After the completion of the subject the students are able to know its Scientific and technological applications in addition with social, economic and environmental implications.*

Module-I: Basic Nuclear Properties and Interaction of Radiation with Matter (15 Hrs)

Basic Nuclear Properties: Nuclear mass, Nuclear size : Nuclear Radius & its determination by Rutherford scattering, electron scattering & mirror nuclei method, Nuclear quantum numbers, Angular momentum, nuclear dipole moment, electric quadruple moment, Nuclear Binding , average binding energy and its variation with mass number, Semi empirical mass formula & its applications.

Module-II: Interaction of nuclear radiation with matter and elementary particles (15 Hrs)

Interaction of charged particles & electromagnetic rays with matter, range, straggling, stopping power, interaction of alpha, beta, gamma rays with matter, absorption law of gamma rays, photoelectric effect, Compton effect, pair production, annihilation of electron- positron pair

Nuclear Detectors: Classification, Ionization chamber: Principle, construction and working,

Proportional counter: Principle, construction and working,

Geiger Muller counter: Principle, construction and working (pulse formation, dead time, recovery time etc), quenching of discharge, Regions of multiplicative operations,

Scintillation Detector: photo multiplier tube, organic and inorganic scintillators, scintillation process, theory, characteristic and detection efficiency

Semiconductor Detector: properties, types (diffuse junction and surface barrier), Li drifted junction detector

Elementary particles: classification, their interaction, types: weak, strong and electromagnetic interactions, their quantum numbers (charge, lepton number, baryon number, iso-spin, strangeness etc), conservation laws: elementary ideas of CP and CPT invariance, Quark theory: assumptions, properties, classification, Gell- Mann mass formula colour of quark & its importance.

Module-III: Nuclear Forces and Nuclear Models (15 Hrs)

Nuclear Forces: Introduction , properties, characteristics, spin dependence of nuclear forces, charge independence & charge symmetry of nuclear forces, Elements of two body problem (Deuteron), its properties, Meson theory of nuclear forces, exchange force and tensor forces, its properties, neutron-proton scattering at low energy, partial wave analysis, phase shift.

Nuclear Models:

Nuclear shell model: spin orbit coupling, nuclear magic numbers, experimental evidences of magic numbers, Angular momenta and parities of nuclear ground states, significance, achievements and limitations, magnetic moment and Schmidt lines.

Liquid drop model: assumptions, achievements, Bohr Wheeler theory of fission, Failure and limitations of liquid drop model,
Collective model: vibration and rotation states, achievements of Bohr and Mottelson collective model
Fermi gas model: assumptions, achievements, limitations of Fermi gas model

Module-IV: Nuclear decay & Nuclear decay Reactions (15 Hrs)

Radioactive decay, laws of successive transformation, dosemetry, nuclear reactions: types, kinematics, transmutation, fission & fusion concept, energy production in stars, P-P and C-N cycles .
β – decay, three forms of β- decay, Fermi and Gamow Teller transitions, Fermi theory of β- decay, Kurie plot, Angular momentum and parity, selection rules, allowed and forbidden transitions, non conservation of parity in β- decay, neutrino hypothesis: detection and properties.

Reference Books:

1. Nuclear Physics, D.C.Tayal,(Himalaya Publishing House, Mumbai)
2. Introduction to Elementary Particles, D. Griffiths, 2nd Ed., Academic Press, 2008.
3. Introductory Nuclear Physics, S.S.M. Wong, 2nd Ed., Wiley VCH, 2004
4. Nuclear Physics, Kaplan, Addison Wesley, (Indian Ed., from Narosa Publishing House, New Delhi), 2002.
5. Introduction to nuclear physics , S.B Patel
6. Concept of Nuclear Physics, B.L. Cohen, McGraw-Hill, 2003.
7. Nuclear & Particle Physics: An Introduction, B. Martin, Willey, 2006.

PHYET 402A – Skill Enhancement Course III - Astrophysics-II

Credits: **04**	*Contact Hours*: **60** *(L+T+R)*	*Total Marks:* **100** **[MSA: 50** (*T1+T2+HA=20+20+10)*; **ESA=*50*]**

Learning Objectives: *Since ancient times, mankind has gazed up at the night sky and wondered. How large is the universe? How old is it? Did it have a beginning, and if so, how old is it? Will it have an end? How did the Earth form and how did life originate? Astrophysics-II course is intended to provide students with adequate knowledge on the formation, structure and composition of the Milky Way and other galaxies in the Universe, active galaxies and active galactic nuclei, interaction among the galaxies in dense environment, expansion of the Universe, theory of general relativity, non-Euclidean space-time geometry and Cosmological models. It also introduces the students to the standard Cosmological model, the open questions and the current research lines in the field. The pre-requisite of this course is that the students have studied Astrophysics-I skill enhancement elective course offered by the School in Semester-III.*

Learning Outcomes: *The students after completing this course along with the laboratory course will Understand the bases of advanced topics selected at the frontier of high energy physics, astrophysics and cosmology and apply them consistently, apply the theory of cosmic perturbation to the problem of the formation of the structure of the universe, distinguish and analyze the problems of the classic Big Bang theory. The students through this course will be able to ddistinguish between the different types of active galaxies, tackle the problem of the evolution of galaxies in its totality, and understand the fundamentals and evolution of the Milky Way. This course provides good base for the students to further their higher studies for M.Phil and Ph.D. in the field of Astronomy & Astrophysics. After successful completion of the Masters' degree with good scores, the students have opportunities to join leading research institutes in the field as research scholars leading to the Ph.D. and also to become astrophysicists, scientists or research officers in the field of space research in various institutes within India and in foreign countries. They can also join teaching profession in universities, colleges and institutes after clearing NET exam conducted by CSIR, New Delhi.*

Module-I: The Milky Way and ISM (15 Hrs)

True shape and size of the Milky Way, Stellar populations, Differential rotation (kinematics) and estimation of mass of the Milky Way, Oort's analysis, Galactic center, Galactic plane. Spiral structure of the Milky Way.

Interstellar Matter: Composition and properties of interstellar matter, dust extinction, color excess, Visual absorption. Interstellar reddening law and Polarization.

Stellar masses and radii – measuring masses in binary stars - visual binary, eclipsing binary, spectroscopic binary; Gravity in close binary, X-ray binaries

Module-II: Extragalactic Universe (15 Hrs)

Classification of galaxies: Hubble's tuning fork diagram, Elliptical galaxies, Lenticular galaxies, Spiral galaxies, Irregular galaxies, spiral structure, distribution of light and mass in regular galaxies.

Gamma-ray bursts & Active galactic nuclei; Accretion process in astrophysics; Astrophysical jets - emission from jets and beaming, Active galaxies: Seyfert galaxies, Radio galaxies, Quasars.

Interaction of galaxies, mergers, clusters of galaxies.

Extra-galactic distance scale, expansion of the universe: Hubble law.

Module-III: General Relativity (15 Hrs)

Review of tensor calculus: Idea of Euclidean and non-Euclidean space, Metric tensor and its properties, Concept of curved spaces and space-times, tensor algebra, Covariant differentiation, Parallel transport, Geodesics, principle of equivalence, action principle and energy tensor, Bianchi Identities, vanishing of Riemann-Christoffel tensor as the necessary and sufficient condition of flatness, Ricci tensor, Einstein tensor.

Einstein's field equations**,** the Newtonian limit. Derivation of Schwarzschild metric: properties and nature of the Schwarzschild metric at R=2M surface

Experimental tests of general relativity: gravitational red shift, perihelic shift of planet mercury, bending of star light-black holes.

Module-IV: Gravity Waves and Cosmology (15 Hrs)

Concept of Gravitational Waves, wave equation in linearised theory, Plane waves, transverse traceless gauge, effect on test particles, principles of detection and generation of gravitational waves, types of detectors, the LIGO detector.

Newtonian cosmology, Einstein universe, expanding universe, simplifying assumptions of cosmology (Robertson-Walker line element), cosmological red-shift, Hubble's law.

Einstein field equations in cosmology, solution of Friedmann's equations- Euclidean, closed and open sections, space-time singularity, luminosity distance (Einstein de Sitter model, closed model and open model), cosmological models with the -term.

Tutorials - will involve problem solving on the topics of the course.

Reference Books:

1. Modern Astrophysics – B.W. Carroll and D.A. Ostlie, 1996, Addison-Wesley Publishing Co., Inc.
2. Quasars and Active Galactic Nuclei, A. K. Kembhavi and J. V. Narlikar, Cambridge University Press.
3. Introduction to Cosmology – J.V. Narlikar, 1995, Cambridge University Press, Cambridge.
4. General Relativity and Cosmology – J.V. Narlikar, Macmillan Co. of India Ltd., New Delhi.
5. Classical Theory of Fields, Vol. 2, L. D. Landau and E. M. Lifshitz, Oxford : Pergamon Press.
6. Structure Formation in the Universe, T. Padmanabhan,Cambridge University Press.
7. Fundamental Astronomy – ed. H. Karttunen, P. Kroger, H. Oja et al., 1987, Springer-Verlag, Berlin.
8. The New Cosmos, 4th edition - A. Unsold and B. Baschek, 1991, Springer-Verlag, Berlin.
9. The Physical Universe: An Introduction to Astronomy – Frank H. Shu, 1982, University Science Books, Sausalito, California.
10. Astrophysics: Stars and Galaxies – K.D. Abhyankar, 1992, Tata McGraw Hill Publishing Co., New Delhi.

11. Text Book of Astronomy and Astrophysics with Elements of Cosmology – V.B.Bhatia, 2001, Narosa Publishing House, New Delhi.
12. Structure Formation in the Universe – T. Padmanabhan, Cambridge University Press.
13. General Relativity – I.R. Kenyon, Oxford University Press.
14. General Relativity, Astrophysics and Cosmology – A.K.Raychaudhuri, S.Banerji and A.Banerjee (Springer-Verla, 1992)
15. First course in general relativity - B. F. Schutz Cambridge: Cambridge university press.
16. Cosmology and Astrophysics through Problems – T. Padmanabhan (Cambridge Univ Press)
17. Introduction to Modern Cosmology - Andrew Liddle
18. Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity (WSE) - S. Weinberg

PHYET 402B – Skill Enhancement Course III - Materials Science-II

***Credits:* 04**	***Periods*: 60** *(L+T+R)*	***Total Marks:* 100** **[MSA: 50** (*T1+T2+HA=20+20+10)*; **ESA=50]**

Course Objective: *1. To introduce the world of Nanoscience to the students, to focus on basic concepts & selected methods of preparation, and to explain the importance and applications of Nanoscience to society and various industries.*
2. To shed light on various novel materials with variety of properties having societal importance & applicability
3. To bring into notice the basic concepts of polymeric materials and to explain the importance of polymeric materials to humanity
4. To introduce the working principle of various characterization techniques used for analyzing various types of materials

Course Outcome: *Upon successful completion of these modules, students will be able to understand that nanoscience is a multidisciplinary field. They will be able to know the characteristics of nanomaterials, various research fields therein and general applications. Students will be able to understand various ceramic materials, biomaterials and composites with their applications in diverse fields. Students will get acquainted with various concepts for polymers and will be able to calculate weight of polymers, chain length, and degree of polymerization. Students will able to understand the working principle of various characterization techniques and will be able to analyze the samples using various techniques.*

Module-I: Nanomaterials (15 Hrs)

Introduction to nanomaterials, importance of nanoscale, classification of nanomaterials, quantum size effect, characteristics & properties of nanomaterials, Clusters, Metallic nanoparticles, magic numbers, geometric structure, semiconducting nanoparticles, Optical Properties of Clusters , synthesis of nanoparticles, applications

Module-II: Novel Materials (15 Hrs)

Ceramics, structures, classification, Phase diagram of ZrO_2-CaO, SiO_2-Al_2O_3, Al_2O_3-Cr2O3, fracture, brittle fracture, Griffth's theory of ceramics, silicates ceramics, structure of silicates, influence of porosity, composites, biomaterials & biosensors

Module-III: Polymers (15 Hrs)

Introduction, degree of polymerization, average molecular weight, molecular structure, molecular configuration, Thermoplastic & thermosetting polymers, copolymers, polymer crystallinity, mechanisms of polymerization, diffusion in polymers, polymer types(plastics, elastomers, fibers), applications of polymers (coatings, adhesives, films, foams), polymer additives.

Module-IV: Characterization Techniques (15 Hrs)

Scanning Electron Microscopy (SEM), Atomic Force Microscopy (AFM), X-Ray Diffraction (XRD), X-ray photoelectron spectroscopy (XPS), Thermo Gravimetric /Differential thermal Analysis (TG/DTA), Atomic Absorption Spectroscopy (AAS), Nuclear Magnetic Microscopy (NMR), Electron Spin Spectroscopy (ESR)

Reference Books:

1.Materials Science and Engineering An Introduction, William Callister, Jr., (Wiley India)

2. Materials Science and Engineering , V.Raghavan, Prentice-Hall of India PVT

3.Nanoscale Science and Technology, R.Kelsall, I.Hamley, M. Geoghegan, Wiley

4. Nanotechnology: Basic calculations for Engineers and Scientists, L. Theodore

5. Fundamentals of Molecular Spectroscopy, Banwell and McCash , Tata McGraw-Hill Publishing Company Ltd.

6. Analytical Techniques, Skoog

PHYET 403A – Skill Enhancement Course IV - Electronics II: Microwave systems, measurements and advanced applications

Credits: 04	Contact Hours: 60 *(L+T+R)*	*Total Marks:* 100 **[MSA: 50** (*T1+T2+HA=20+20+10)*; **ESA=*50*]**

Course Objectives: *This paper mainly concentrates on Microwave systems, Microwave electronics measurements, Material Characterization and applications. It has covered basic of Microwave Electronics systems as well as applied aspects of Microwaves. The Scientific, Industrial and Medical Applications covering Microwave heating Sensor, medical and Remote sensing through microwave are included in the paper.*

Course Outcome: *This enables the students to understand the Material Characterization and Communication systems. Moreover, the method of measurements using advanced techniques such Network Analyser and RADAR are also included in this paper. This specific study enables the student to work in R & D organizations for further studies and jobs in private/Govt. Sectors.*

Module-I: Microwave Measurements (15 Hrs)

Frequency measurements, measurement of power, attenuation measurements, measurement of Phase Shift, measurement of voltage standing wave ratio VSWR, measurement of impedance, measurement of insertion loss, measurement of dielectric constant, measurement of noise factor, measurement of Q of a cavity resonator.

Module-II: Microwave for material characterization and other applications (15 Hrs)

Microwave for material characterization

Microwave measurement of material characterization, Dielectric Properties of Materials, Permeability and conductivity. Network Analyzer and Time Domain Reflectometry

Scientific and Industrial applications of Microwaves:

Scientific, Industrial and Medical Applications:

Microwave Heating, High Energy Scientific Application, Microwave Processing of Electronic Materials, Microwave Assisted Chemistry, Active and Passive Sensors and Systems, Medical Diagnosis and Imaging, Medical Application of microwave Navigation and Other Microwave System, Remote sensing through microwaves.

Module-III: Microwave Communication Systems (15 Hrs)

Introduction, propagation modes, microwave communication systems, analog microwave communication, satellite communication, digital microwave communication, Microwave antennas: horn antennas, paraboloids or microwave dish antennas, lens antennas, slot antennas, microstrip antennas and aperture antennas.

Module IV: RADAR System (15 Hrs)

Radar: Introduction, Radar block diagram and operation, radar equation, factors affecting range of radar, maximum unambiguous range, pulse radar system, radar display, scanning and tracking with radar, Doppler effect, CW Doppler radar, MTI, frequency modulated CW radar and radar antennas.

Reference Books:

1. Microwave Radar Engineering- *by M. Kulkarni, Umesh Publicatios, New Delhi.*
2. Microwave Devices and Applications by Dinesh C Dube Narosa Publishing House New Delhi
3. Understanding Microwaves-*by Allan W. Scott, A. John Wiley & Sam Ins. Publications*
4. The Microwave Engineering Handbook Vol. I, II and III *–by L. Smith & Michel Henri Carpentire, Springer Industrial edition.*
5. Microwave Devices and circuits- by *Samuley Y. Liao, Prentice Hall of Gredia Private Limited, New Delhi.*
6. Microwave Circuits and Passive devices-*by M.L. Sisodia &G.S. Raghuvanshi, Wiley Eastern Limited, New Delhi.*
7. Microwave Engineering- *by Sanjeev Gupta, Khanna Publication, New Delhi.*
8. Electronics Communication System *–by Kennedy George, McGraw Hill book Company*
9. Communication Componants & Circuits-*by Edgar Hund, Mc-Graw Hill*
10. “Binary Polar Liquids” Structure and Dynamic Characterization using Spectroscopy Methods- by Suresh Mehrotra, Ashok Kumbharkhane and Ajay Chaoudhari. Elsevier Publication. ISBN: 978-0-12-813253-1.

PHYET 403B – Skill Enhancement Course IV - Fiber Optics and Lasers-II

Credits: 04	Contact Hours: 60 *(L+T+R)*	*Total Marks:* 100 **[MSA: 50** *(T1+T2+HA=20+20+10)*; **ESA=50]**

Learning Objective: *This paper is designed to cover in details about the solid state lasers and respective detectors used. Along with this it gives understanding to students about the characteristics of fibers through experimental analysis of the fiber and its losses.*

Learning outcome: *Upon successful completion of our fiber optic and laser-IIpaper, the student gets knowledge of solid state lasers and the detectors. The experimental part in this paper will provide hand on training on different parameters of fibers which may decay the signal transport through fiber.*

Module-I: Optical Sources (15 Hrs)

- Types of optical light sources.
- Injection laser diodes
- Optical emission from semiconductor, spontaneous emission carrier recombination. Other radiative recombination processes.
- Stimulated emission and lasing,
- heterojunctions,
- semiconductor materials, semiconductor injection lasers efficiency.
- Strip geometry, laser modes, injection laser structure: gain guided and index guided structures. Injection lasers characteristics
- Light emitting diodes: LED power and efficiency, double hetrojunction LED, surface emitter LEDs and Edge emitted LEDs, LED characteristics

Module-II: Optical Detectors (15 Hrs)

- Optical detection principle, photoelectric effect, absorption, quantum efficiency and responsivity
- p-n and p-i-n photodiodes
- Speed of response, detector noise, signal to noise ratio, detectivity, beat error rate, noise equivalent power typical fiber optics sensor.
- Photodiode with internal gain, avalanche photodiode and silicon reach through APDs.
- Light detection techniques (photodiode, CCD, CMOS, PMT and scintillation)

Module-III: Transmission Characteristics of Optical Fibers (15 Hrs)

- Attenuation
- Material absorption losses
- Linear scattering losses
- Nonlinear scattering losses
- Dispersion: intramodal and intermodal

Module-IV: Optical Fiber Measurements (15 Hrs)

- Fiber attenuation measurement
- Fiber dispersion measurement
- Fiber refractive index profile measurement
- Fiber cutoff wavelength measurement
- Fiber numerical aperture measurement
- Fiber diameter measurement
- Mode field diameter of single mode fiber
- Reflectance and optical return loss and optical time domain reflectometery

References Books:

1. Optical Fiber communications: Principles and Practices – John M. Senor (Phi)
2. The Elements of Fiber Optics – S. L. W. Meardon (Regents and Ph)
3. Optical Fiber communications – Ger Keiser (Mcgraw Hill)
4. Introduction Of Fiber Optics- A Ghatak And Tyagrajan (Cambridge University Press)
5. Fiber Optic communications – Joseph C. Palais

PHYOT 404 – Open Elective-II - (From other School)

Credits: **04**	***Contact Hours*****: 60** *(L+T+R)*	***Total Marks:*** **100** **[MSA: 50** (*T1+T2+HA=20+20+10)*; **ESA=*50*]**

PHYCL 411 Nuclear Physics Laboratory (Core - 19)

***Credits:* 02**	***Contact hours*: 30** *(Hands-on)*	***Total Marks:* 50** **[ESA=*50*]**

Nuclear Physics Laboratory Experiments

1. Study the characteristics of a GM tube and determination of its operating voltage.
2. Determination of the dead time using single source.
3. Study of nuclear counting statistics.
4. Verification of Inverse square law for γ- rays.
5. Attenuation of β- rays
6. Measurement of short half-life.
7. Measurement of long half-life.
8. Calibration of Gamma-ray spectrometer using Cesium and Cobalt 60 sources.
9. Determination of energy of any unknown gamma source.

PHYEL 412A Skill Enhancement Laboratory-III - Astrophysics Laboratory-III

***Credits:* 02**	***Contact hours*: 30** *(Hands-on)*	***Total Marks:* 50** **[ESA=*50*]**

Learning Objectives and Outcome: *Objective of this Laboratory course is to introduce the students to the practical applications of the Skill Enhancement Course (PHYET 402A) that the students have studied in Semester III. After completing this course student will be able to understand the characteristics and handling of the instruments, understand the properties of the Sun and other stars in the Milky Way. Each student appearing forsemester end examination must produce a journal showing that he has completed* ***at least 6*** *experiments of this paper during the year.*

Astrophysics Laboratory –II Experiments

1. Polar aligning a telescope and measuring declination of Polaris
2. Measuring distance to Moon by parallax method
3. Identifying and measuring diameters of Craters on the Moon surface
4. Finding rotation period of the Sun by measuring motion of sun-spots
5. Estimating temperature of an artificial star
6. Fraunhofer lines in the Sun spectrum
7. Temperature of flame by line reversal method
8. Estimating mass of Jupiter using Kepler's laws of planetary motion
9. Measurement of distance of star clusters by main sequence fit method
10. Measuring duty cycle and period of a pulsar (CLEA)
11. BVRI photometry of stars and estimating their effective surface temperatures (CLEA)
12. Studying limiting magnitude and resolving power of 8' LX50 telescope
13. Studying atmospheric extinction of star light

PHYEL 412B Skill Enhancement Laboratory-III - Material Science Lab -III

***Credits:* 02**	***Contact Hours*: 30** *(Hands-on)*	***Total Marks:* 50** **[ESA=*50*]**

Material Science Laboratory-III Experiments

1. To calculate the speed of rotary pump.
2. To study adsorption of oxalic acid on charcoal and to study adsorption isotherm by Freundlich equation.
3. To determine the diffusion coefficient of Fe^{3+} /Co^{2+} / Ni^{2+} ions by using egg membrane.
4. To determine the diffusion coefficient of Fe^{3+} /Co^{2+} / Ni^{2+} ions by using agar gel.
5. To study adsorption of vapours on adsorbent and to study adsorption isotherm.
6. To fractionate human serum proteins by Paper electrophoresis

PHYEL 413A Skill Enhancement Laboratory-IV - Electronics Laboratory-III

Credits: **02**	*Contact hours*: **30** *(Hands-on)*	*Total Marks:* **50** **[ESA=*50*]**

Microwave Electronics Laboratory Experiments:

1. Measurement of Dielectric constant of a given sample.
2. To study the substitution method for measurement of attenuation and hence.
   I. To determine attenuation due to a component under test.
   II. To study variations in its attenuation with the frequency
3. To measure an unknown impedance using smith chart
4. To study the properties of 3-port circulator and determine the scattering parameters of circulator.
5. To study the phase shifter
6. 16. To study the square law behavior of a microwave crystal detector

PHYEL 413B Skill Enhancement Laboratory-IV - Fiber Optics & Lasers Lab - III

Credits: **02**	*Contact hours*: **30** *(Hands-on)*	*Total Marks:* **50** **[ESA=*50*]**

Fiber Optics and Lasers Laboratory Experiments

1. To determine the Power distribution within the laser beam.
2. To determine the Spot size of the laser beam.
3. Plot power distribution of laser at two locations and hence determine the divergence of the laser beam
4. To determine the grating constant for a given grating by means of the laser beam.
5. Find out the laser wavelength by means of given grating (grating constant= 0.08mm)
6. Observe the diffraction of the laser beam from a given vernier scale and find the wavelength of laser beam.
7. Show the diffraction pattern from the vernier scale and hence determine the minimum distance between adjacent two lines on vernier.

PHYCL 414 Project Dissertation (Core 20)

***Credits:* 04**	***Contact hours*: 60** *(Hands-on)*	***Total Marks:* 100** **[MSA=50, ESA=*50*]**

Every students admitted to M Sc Physics third semester have to complete one project dissertation of 4 credits (100 marks) under the guidance of the faculty member as allocated him in the beginning of the third semester. The performance of the student in project work shall be assessed in both the modes i.e., the MSA of 50 marks and the ESA of 50 marks. ESA will be conducted by a panel of external examinations, where the candidate shall give a presentation on the work that he has conducted throughout the year.

Question Paper Pattern
Semester End Assessment
M. Sc. Physics First and Second Year (CBCS)

Time: 03 Hrs **Total Marks: 50**

Note: All questions are compulsory and carry equal marks

Question 1 – Long answer type (10 marks) or two sub-questions (each of 5 marks) **10 marks**

OR

Long answer type (10 marks) or two sub-questions (each of 5 marks) **10 marks**

(Note: This question will be based on Module I)

Question 2 – Long answer type (10 marks) or two sub-questions (each of 5 marks) **10 marks**

OR

Long answer type (10 marks) or two sub-questions (each of 5 marks) **10 marks**

(Note: This question will be based on Module II)

Question 3 – Long answer type (10 marks) or two sub-questions (each of 5 marks) **10 marks**

OR

Long answer type (10 marks) or two sub-questions (each of 5 marks) **10 marks**

(Note: This question will be based on Module III)

Question 4 – Long answer type (10 marks) or two sub-questions (each of 5 marks) **10 marks**

OR

Long answer type (10 marks) or two sub-questions (each of 5 marks) **10 marks**

(Note: This question will be based on Module II)

Question 5 – Write Short Notes on ANY TWO (each of 5 marks) **10 marks**

a.
b.
c.
d.

(Note: This question shall be based on entire syllabus and must have one sub-question from each of the module)

Question Paper Pattern for Practical Course
M Sc Physics (CBCS)

Time: 03 Hrs **Total Marks: 50**

Note: ***i. Every student is required to complete one experiment in the final examination***
ii. The distribution of the 40 marks will be as given below

Q-1	**(a) Experimental work**	**35** ***marks***
	(b) Calculations, Units, Results, Graphs, etc.	**05** ***Marks***
	(c) Viva-voce	***05 marks***
	(d) Journal	***05 marks***

(***Dr. M. K. Patil***)
Chairman, BOS in Physics