NAAC grade 'A'

KCG grade 'A'

ACADEMIC REGULATIONS & SYLLABUS

Faculty of Applied Sciences

Master of Science Program

(Physics)

Education Campus – Changa, (ECC), hitherto a conglomerate of institutes of professional education in Engineering, Pharmacy, Computer Applications, Management, Applied Sciences, Physiotherapy and Nursing, is one of the choicest destinations by students. It has been transformed into **Charotar University of Science and Technology (CHARUSAT)** through an Act by Government of Gujarat. CHARUSAT is permitted to grant degrees under Section-22 of UGC- Govt. of India.

The journey of CHARUSAT started in the year 2000, with only 240 Students, 4 Programmes, one Institute and an investment of about Rs.3 Crores (INR 30 million). At present there are seven different institutes falling under ambit of six different faculties. The programmes offered by these faculties range from undergraduate (UG) to Ph.D. degrees. These faculties, in all offer 64 different programmes. A quick glimpse in as under:

Faculty	Institute	Programmes Offered
Faculty of Technology & Engineering	Charotar Institute of Technology	B. Tech M. Tech MTM Ph. D
Faculty of Pharmacy	Ramanbhai Patel College of Pharmacy	B. Pharm M. Pharm MPM PGDCT/ PGDPT Ph. D
Faculty of Management Studies	Indukaka Ipcowala Institute of Management	M.B.A PGDM Dual Degree BBA+MBA Ph.D
Faculty of Computer Applications	Smt. Chandaben Mohanbhai Patel Institute of Computer Applications	M.C.A/MCAL M.Sc (IT) Dual Degree BCA+MCA Ph. D
Faculty of Applied Sciences	P.D.Patel Institute of Applied Sciences	M.Sc Dual Degree

		B.Sc+M.Sc Ph.D
Faculty of Medical Sciences	Ashok and Rita Institute of Physiotherapy Manikaka Topawala Institute of Nursing Charotar Institute of Paramedical Sciences	B.PT M.PT Ph.D B.Sc (Nursing) M.Sc PGDHA PGDMLT GNM Ph.D

The development and growth of the institutes have already led to an investment of over Rs.125 Crores (INR 1250 Million). The future outlay is planned with an estimate of Rs.250 Crores (INR 2500 Million).

The University is characterized by state-of-the-art infrastructural facilities, innovative teaching methods and highly learned faculty members. The University Campus sprawls over 105 acres of land and is Wi-Fi enabled. It is also recognized as the Greenest Campus of Gujarat.

CHARUSAT is privileged to have 360 core faculty members, educated and trained in IITs, IIMs and leading Indian Universities, and with long exposure to industry. It is also proud of its past students who are employed in prestigious national and multinational corporations.

From one college to the level of a forward-looking University, **CHARUSAT** has the vision of entering the club of premier Universities initially in the country and then globally. **High Moral Values like Honesty, Integrity and Transparency** which has been the foundation of ECC continues to anchor the functioning of **CHARUSAT**. Banking on the world class infrastructure and highly qualified and competent faculty, the University is expected to be catapulted into top 20 Universities in the coming five years. In order to align with the global requirements, the University has collaborated with internationally reputed organizations like Pennsylvania State University – USA, University at Alabama at Birmingham – USA, Northwick Park Institute –UK, ISRO, BARC, etc.

CHARUSAT has designed curricula for all its programmes in line with the current international practices and emerging requirements. Industrial Visits, Study Tours, Expert Lectures and Interactive IT enabled Teaching Practice form an integral part of the unique **CHARUSAT** pedagogy.

The programmes are credit-based and have continuous evaluation as an important feature. The pedagogy is student-centred, augurs well for self-learning and motivation for enquiry and research, and contains innumerable unique features like:

- Participatory and interactive discussion-based classes.
- Sessions by visiting faculty members drawn from leading academic institutions and industry.
- Regular weekly seminars.
- Distinguished lecture series.
- Practical, field-based projects and assignments.
- Summer training in leading organizations under faculty supervision in relevant programmes.
- Industrial tours and visits.
- Extensive use of technology for learning.
- Final Placement through campus interviews.

Exploration in the field of knowledge through research and development and comprehensive industrial linkages will be a hallmark of the University, which will mould the students for global assignments through technology-based knowledge and critical skills.

The evaluation of the student is based on grading system. A student has to pursue his/her programme with diligence for scoring a good Cumulative Grade Point Average (CGPA) and for succeeding in the chosen profession and life.

CHARUSAT welcomes you for a Bright Future

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

Faculty of Applied Sciences

ACADEMIC REGULATIONS

Master of Science (Physics) Programme

Charotar University of Science and Technology (CHARUSAT)
CHARUSAT Campus, At Post: Changa – 388421, Taluka: Petlad, District: Anand
Phone: 02697-247500, Fax: 02697-247100, Email: info@charusat.ac.in
www.charusat.ac.in

Year – 2016-2017

M. Sc. (Physics) Programme

CHARUSAT

FACULTY OF APPLIED SCIENCES
ACADEMIC REGULATIONS

Faculty of Applied Sciences

To ensure uniform system of education, duration of post graduate programmes, eligibility criteria for and mode of admission, credit load requirement and its distribution between course and system of examination and other related aspects, following are the academic rules and regulations.

1. *System of Education*

The Semester system of education shall be followed across The Charotar University of Science and Technology (CHARUSAT) at Master's levels. Each semester will be at least 90 working day duration. Every enrolled student will be required to do a specified course work in the chosen subject of specialization and also complete a project/dissertation if any. Medium of instruction will be English

2. *Duration of Programme*

Postgraduate programme	(M.Sc.)
Minimum	4 semesters (2 academic years)
Maximum	6 semesters (3 academic years)

The maximum limit can be extended by 1 or 2 semester subject to the approval of university on case to case basis.

3. *Eligibility for admissions*

For the admission to M.Sc., programs in the subject of Biological/Physical/Mathematical/Chemical Sciences a candidate must have obtained a Degree of Bachelor of Science from any recognized University or a Degree recognized as equivalent thereto, with minimum Second Class.

4. *Mode of admissions*

Admission to M.Sc. programme will purely on combined merit of admission test and performance at graduation.

5. *Programme structure and Credits*

A student admitted to a program should study the course and earn credits specified in the course structure.

6. *Attendance*

6.1 All activities prescribed under these regulations and listed by the course faculty members in their respective course outlines are compulsory for all students pursuing the courses. No exemption will be given to any student from attendance except on account of serious personal illness or accident or family calamity that may genuinely prevent a student from attending a particular session or a few sessions. However, such unexpected absence from classes and other activities will be required to be condoned by the Dean/Principal.

6.2 Student attendance in a course should be 80%.

7. *Course Evaluation*

7.1 The performance of every student in each course will be evaluated as follows:

7.1.1 Internal evaluation by the course faculty member(s) based on continuous assessment, for 30% of the marks for the course; and

7.1.2 Final examination will be conducted by the University t for 70% of the marks for the course.

7.2 *Internal Evaluation*

7.2.1 Internal evaluation will be based on internal tests and several other tools of assessment like, quiz, viva, seminar etc., as prescribed by concerned teacher and decided by the faculty.

7.3 Internal Institutional evaluation for practicals

7.3.1 One internal practical test/viva will be conducted per semester totaling to 30 % internal marks for practicals

7.3.2 In “Continuous evaluation” Students shall be evaluated in a continuous manner for their involvement in the practical, aptitude for learning, completion of practical related assignments, regularity in the practicals and record keeping

7.4 University Examination

7.4.1 The final examination by the University for 70% of the evaluation for the course will be through written paper or practical test or oral test or presentation by the student or a combination of any two or more of these.

7.4.2 In order to earn the credit in a course a student has to obtain grade other than FF.

7.5 Performance at Internal & University Examination

7.5.1 Minimum performance with respect to internal marks as well as university examination will be an important consideration for passing a course.
Details of minimum percentage of marks to be obtained in the examinationsareas follows

Minimum marks in University Exam per subject	Minimum marks Overall per subject
40%	50%

7.5.1. If a candidate obtains minimum required marks per subject but fails to obtain minimum required overall marks, he/she has to repeat the university examination till the minimum required overall marks are obtained.

8 Grading

8.1 The internal evaluation marks and final University examination marks in each course will be converted to a letter grade on a ten-point scale as per the following scheme:

Grading Scheme:

Range of Marks (%)	≥80	≥75 <80	≥70 <75	≥65 <70	≥60 <65	≥55 <60	≥50 <55	<50
Letter Grade	AA	AB	BB	BC	CC	CD	DD	FF
Grade Point	10	9	8	7	6	5	4	0

8.2 The student's performance in any semester will be assessed by the Semester Grade Point Average (SGPA). Similarly, his performance at the end of two or more consecutive semesters will be denoted by the Cumulative Grade Point Average (CGPA). The SGPA and CGPA are calculated as follows:

(i) SGPA = $\sum C_i G_i / \sum C_i$ where C_i is the number of credits of course i
G_i is the Grade Point for the course i
and i = 1 to n, n = number of courses in the semester

(ii) CGPA = $\sum C_i G_i / \sum C_i$ where C_i is the number of credits of course i
G_i is the Grade Point for the course i
and i = 1 to n, n = number of courses of all semesters up to which CGPA is computed.

(iii) No student will be allowed to move further if CGPA is less than 3 at the end of every academic year.

9. Awards of Degree

9.1 Every student of the programme who fulfils the following criteria will be eligible for the award of the degree:

9.1.1 He/ She should have earned at least minimum required credits as prescribed in course structure; and

9.1.2 He/ She should have cleared all internal and external evaluation components in every course; and

9.1.3 He/ She should have secured a minimum CGPA of 5.0 at the end of the programme;

9.1.4 In addition to above, the student has to complete the required formalities as perthe regulatory bodies.

10 Award of Class:

The class awarded to a student in the programme is decided by the final CGPA as per the following scheme:

CGPA	CLASS
Less than 5.0	Successfully completed
5.00 and Less than 6.00	Second Class
6.00 and Less than 7.50	First class
7.50 and above	First Class with Distinction

11 Transcript:

The transcript issued to the student at the time of leaving the University will contain a consolidated record of all the courses taken, credits earned, grades obtained, SGPA,CGPA, class obtained, etc.

Credit system

- Faculty of Applied Sciences
- Department of Physical Sciences
- **Course: M.Sc.**
- **Subject: M.Sc. Physics**
- Academic period: 2016 onwards

Course	**Credits**				Total
	I	II	III	IV	
Core Compulsory	17	20	15	08	64
Core Allied/Electives	05	02	07	14	24
Foundation course	03	03	03	03	12
Total	**25**	**25**	**25**	**25**	**100**

Course Details

1. Core Courses:

Subject Code	Subject Title
PS 711	Mathematical Methods in Physics -I
PS 712	Classical Mechanics-I
PS 713	Thermodynamics and Statistical Mechanics
PS 714	Solid State Physics –I
PS 717	Mathematical Methods in Physics -II
PS 718	Classical Mechanics-II
PS 719	Quantum mechanics - I
PS 720	Electromagnetic Theory -I
PS 721	Electronics
PS 901	Electromagnetic Theory -II
PS 905	Atomic Physics
PS 951	Molecular Physics
PS 952	Nuclear and Particle Physics
PS 953	Solid State Physics –II
PS 716.01, PS722.01, PS 906	Practical

2. Core Allied/Elective

Subject Code	Subject Title
PS 715	Computer Programming
PS 902	Quantum mechanics - II
PS 907- PS 950	Elective –I
PS 955	Elective -II
PS 1000	Elective -III
PS 954	Project

3. Foundation Courses/University Elective

AW701	Co-curricular activity & Self study
HS 701	Communication skill-I
AW702	Co-curricular activity & Self study
HS 702	Communication skill-I
PS 903	Analytical Techniques
PS 904	Numerical Analysis
####	Elective –I (Sem.1)
####	Elective –II (Sem.2)

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY (CHARUSAT)														
Subjects for M.Sc. Physics Programme – 2016 Onwards														
	Subject Code	Subjects	Teaching scheme				Theory Evaluation			Practical Evaluation			Total I +II
			L+T	P	Contact hrs.	Total Credits	Institute	University	Total-I	Institute	University	Total-II	
Sem I	PS 711	Mathematical Methods in Physics -I	2	-	2	2	15	35	50				50
	PS 712	Classical Mechanics-I	2	-	2	2	15	35	50				50
	PS 713	Thermodynamics and Statistical Mechanics	3+1	-	4	4	30	70	100				100
	PS 714	Solid State Physics -I	2	-	2	2	15	35	50				50
	PS 715	Computer Programming	2	1	3	3	15	35	50	15	35	50	100
	PS 716.01	Practical-I		9	9	7				60	140	200	200
	AW701	Co-curricular activity & Self study			2	1	Audit course						
	**HS701	Advance Critical Thinking and Logic			2	2	30	70	100				100
	#-#-#	University Elective	2		2	2	#-#-#	#-#-#	#-#-#	#-#-#	#-#-#	#-#-#	#-#-#
					28	**25**							**650**

**Humanities and Social Sciences offered by Faculty of Management studies

#-#-# Elective offered across the University

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY (CHARUSAT)													
Subjects for M.Sc. Physics Programme – 2016 Onwards													
	Subject Code	Subjects	Teaching scheme				Theory Evaluation			Practical Evaluation			Total I +II
			L+T	P	Contact hrs.	Total Credits	Institute	University	Total-I	Institute	University	Total-II	
Sem II	PS 717	Mathematical Methods in Physics -II	2	-	2	2	15	35	50				50
	PS 718	Classical Mechanics-II	2+1	-	3	3	30	70	100				100
	PS 719	Quantum mechanics - I	2	-	2	2	15	35	50				50
	PS 720	Electromagnetic Theory -I	2		2	2	15	35	50				50
	PS 721	Electronics	2+1		3	3	30	70	100				100
	PS 722.01	Practical-II		12	12	8				60	140	200	200
	AW702	Co-curricular activity & Self study			2	1	Audit course						
	**HS702	Academic Writing and Communication Skills			2	2	-	-	-	30	70	100	100
	#-#-#	University Elective	2		2	2	#-#-#	#-#-#	#-#-#	#-#-#	#-#-#	#-#-#	#-#-#
					30	**25**							**650**

**Humanities and Social Sciences offered by Faculty of Management studies

#-#-# Elective offered across the University

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY (CHARUSAT)													
Subjects for M.Sc. Physics Programme - 2015													
	Subject Code	Subjects	Teaching scheme				Theory Evaluation			Practical Evaluation			Total I +II
			L+T	P	Contact hrs.	Total Credits	Institute	University	Total-I	Institute	University	Total-II	
Sem III	PS 901	Electromagnetic Theory -II	2	-	2	2	15	35	50				50
	PS 902	Quantum mechanics - II	2	-	2	2	15	35	50				50
	PS 903	Analytical Techniques	2	2	4	3	15	35	50	15	35	50	100
	PS 904	Numerical Analysis	1+1	2	4	3	15	35	50	15	35	50	100
	PS 905	Atomic Physics	2	-	2	2	15	35	50				50
	PS 906	Practical-III		12	12	11				60	140	200	200
	PS 907-PS 950	Elective -I	1+1	-	2	2	15	35	50				50
					28	**25**							**600**

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY (CHARUSAT)														
Subjects for M.Sc. Physics Programme - 2015														
	Subject Code	Subjects	Teaching scheme				Theory Evaluation			Practical Evaluation			Total I +II
			L+T	P	Contact hrs.	Total Credits	Institute	University	Total-I	Institute	University	Total-II	
Sem IV	PS 951	Molecular Physics	2	-	2	2	15	35	50				50
	PS 952	Nuclear and Particle Physics	3	2	5	4	30	70	100	15	35	50	150
	PS 953	Solid State Physics -II	2	-	2	2	15	35	50				50
	PS 954	Project			15	13				100	150	250	250
	PS 955 PS 1000	Elective -II			2	2	15	35	50				50
		Elective -III			2	2	15	35	50				50
					28	**25**							**600**

M. Sc. (Physics) Programme

SYLLABI

(Semester – 1)

CHAROTAR UNIVERSITY OF SCIENCE AND TECHNOLOGY

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc Physics (Semester – I)

PS 711 Mathematical Methods in Physics – I

Credit: 2

A. Objective of the course.

- The objective of the course is to introduce students to various mathematical methods useful in physics.
- To explore the basics mathematical concepts.
- To provide problem solving techniques using these mathematical methods.

B. Outline of the Course

Sr. No.	Title of Unit	No. of hrs.
1.	Vector algebra & Vector Calculus	8h
2.	Linear algebra	10h
3.	Linear differential equations	8h
4.	Fourier series & Fourier transform	5h

A.	**Syllabus Topics:**	**[1L + 1T]**
1.	Vector algebra	[MLB – 6]
2.	Vector calculus	[MLB – 6]
3.	Linear Algebra	[MLB – 3]
4	Linear differential equations	[MLB – 8, 13]
5.	Fourier series & Fourier transform	[MLB – 7]

B . Instructional Methods and Pedagogy:

The topics will be discussed in depth in an interactive class room environment using classical black–boardteaching method and also power–pointpresentations will be used at times. Some mathematical calculations will be visualized using computer programs in a full-fledged computer laboratory. Brain storming sessions on various topics will be conducted in order to develop problem solving skills in the students. Students will be trained to crack national level examinations such as CSIR–JRF, GATE, DRDO, and BARC. Continuous evaluation process will be adopted by conducting small quizzes, class tests, and seminars which will provide the students an opportunity to improve on their performances.

C. Student Learning Outcomes / objectives:

- This course is aimed at providing students with the mathematical concepts and tools needed to understand crucial concepts of various branches of physics.
- At the end of the course the students would be able to apply the mathematical methods to solve the problems of physics conceptually.
- The training that the student would gain will be useful in developing analytical and interpretation skills by correlating mathematical methods to various physics problems.
- At the long run the training provided will impact the students highly in qualifying the national level exams for further career.

D. Recommended Study Material:

Text books/Reference books

1. Mary L Boss [MLB], Mathematical Methods in Physical Sciences, 3rd Edition, John Wiley & Sons, India. {Text Book}.
2. Arfken& Weber, Mathematical Methods for Physicists (6^{th} edition), Elsevier, Academic Press (2012)

3. Erwin Kreyszig, Advanced Engineering Mathematics 8th Edition, Wiley India(p) Ltd.,
4. M R Spiegel, Vector Analysis, New Yourk, McGraw Hill (1989)
5. Heading J, Matrix theory for physicists, London-Logmann Green& Co. (1958)
6. Gilbert J and L Gilbert, Linear Algebra & Matrix theory, Academic Press (1995).
7. Dass H K, Mathematical Physics, S Chand and company 2004
8. P K Chattopadhyay, Mathematical Physics, New Age Iint. P. Ltd., Delhi, 2006.
9. H Margenu, Mathematical physics, East-West Press, 1962.
10. Mathematics of Classical and Quantum Physics – Byron, Fuller Dover (1992)
11. Linear Algebra – Seymour Lipschutz, Schaum Outlines Series- Mc-Graw Hill edition
12. Mathematical Methods of Physics – Mathews & Walker – 2nd Edition- Pearson Edition
13. Fourier Series –Seymour Lipschutz, Schaum Outlines Series
14. Laplace Transform - SeymourLipschutz, Schaum Outlines Series
15. Mathematical Methods in Classical and Quantum Physics – Tulsi Das, S.K.Sharma, University Press India.
16. Mathematical Methods in Physics – Butkov Addition Wesley Publishers.
17. Mathematical Physics, by B.D. Gupta
18. Mathematical Physics, by Rajput.
19. Mathematical Methods for Physicists and Engineers, by K.F. Reily, M.P. Hobson and S.J. Bence

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc. Physics (Semester-I)

PS 712Classical Mechanics-1

Credit: 2

A. Objective of the course.

- The objective of the course is to introduce students to Newtonian mechanics.
- To explore Lagrangian & Hamiltonian dynamics to solve the physics problems.
- This course also covers motion in central force field.

B. Outline of the Course

Sr. No.	Title of Unit	No. of hrs
1.	Concepts of Newtonian mechanics-revisit	5h
2.	Central force motions	5h
3.	Two body Collisions-scattering theory	5h
4.	Generalized coordinates and Lagrangian equations of motion	6h
5.	Hamiltonian formalism and equations of motion	6h

A. Syllabus Topics: [1L +1T]

1. Newtonian mechanics-revisit.
2. Dynamical systems, Phase space dynamics, stability analysis. (Chapter 1 &2, Goldstein)
3. Central force motions. (Chapter 3, Goldstein)
4. Two body Collisions - scattering in laboratory and Centre of mass frames. (Chapter 3, Goldstein)
5. Variational principle. Generalized coordinates. Lagrangian formalism and equations of motion. (Chapter 1 &2, Goldstein)
6. Conservation laws and cyclic coordinates, Hamiltonianformalism and equations of motion. (Chapter 8 & 9, Goldstein)

B . Instructional Methods and Pedagogy:

The emphasis during Lecture sessions will be on Understanding of Concepts rather than on complexities subject. Stress is also given on relevant illustrations provided from the Real World processes. Sufficient home assignments will be given to the students which will test their fundamentals and ability to relate concepts with reality.

C. Student Learning Outcomes / objectives:

- Ensuring that students acquire sound knowledge in classical mechanics.
- At the end students would gain experience in the solving problems in classical mechanics.
- Major emphasis under this course is given on numerical solution, which will make them confident for JRF and any other competitive examinations.

D. Recommended Study Material:

Text books/Reference books

1. Classical Mechanics, H Goldstein, 2nd edition, Addison Wesley Publishing Company.
2. Classical Mechanics – N C Rana and P S Jog, Tata McGraw Hill, 1991.
3. Classical Mechanics,- Yaswant Waghmere.
4. Introduction Classical Mechanics - R. G. Takwale, P. S. Puranik, Tata McGraw Hill.
5. Classical Mechanics – System of particles and Hamiltonian Dynamics' by Greiner, Springer International Ed. 2006.
6. Classical Mechanics by G.Aruldhas, PHI.

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc. Physics (Semester – I)

PS 713Thermodynamics and Statistical Mechanics

Credit: 4

A. Objective of the course.

The objective of the course is

- To introduce students to statistical behavior of physical and chemical phenomena .
- To make the students understand how thermodynamics is built using the concepts of statistical laws and formulations
- To built a basis for understanding various aspects of condensed matter.
- To develop an understanding towards phase transitions of matter from one form to the other.

B. Outline of the Course

Sr. No.	Title of Unit	No. of hrs
1.	Review of thermodynamics	10h
2.	Introduction to probability and their application in statistical physics	12h
3.	Basic principles of statistical mechanics and their application	12h
4.	Theories of phase transitions	6h
5.	Introduction to calculation of thermodynamic properties using Statistical Mechanics and computer simulations	5h

A. **Syllabus Topics:** **[2L + 1T]**

1. Review of thermodynamics [Reif –1, 2,RKP–1]
2. Introduction to probability and their application in statistical physics [KPNM –all]
3. Basic principles of statistical mechanics and their application [RKP – 1,2,3,4,5]
4. Theories of phase transitions [RPK – 13]
5. Introduction to calculation of thermodynamic properties using Statistical Mechanics and computer simulations. [ALT – 2,3,4]

B . Instructional Methods and Pedagogy:

The topics will be discussed in depth in an interactive class room environment using classical black–boardteaching method and also power–pointpresentations will be used at times. Some mathematical calculations will be visualized using computer programs in a full fledged computer laboratory. Brain storming sessions on various topics will be conducted in order to develop problem solving skills in the students. Students will be trained to crack national level examinations such as CSIR–JRF, GATE, DRDO, and BARC. Continuous

C. Student Learning Outcomes / objectives:

- This course is aimed at providing students some statistical tools to uncover various phenomenological problems in nature.
- At the end of the course the student understand the microscopic picture of thermodynamic systems.
- Few small level calculations by the end of the course would provide the students with some flair of statistical physics while applying them to real life problems using computer modeling.

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D. Recommended Study Material:

Text books/Reference books

1. Statistical Mechanics – R. K. Pathria, Paul D. Beale; Elsevier 3rd edition
2. Statistical Mechanics – Franz Schwabl, Springer 2nd edition
3. Monte Carlo: Basics – K. P. N. Murthy
4. Fundamentals of Statistical and Thermal Physics, F. Reif, Levant Books
5. Statistical Mechanics – Kerson Huang, Wiley 2nd edition.

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc. Physics (Semester-I)

PS 714Solid State Physics-I

Credit: 2

A. Objective of the course.

- The objective of the course is to introduce students to understand crystallography without necessarily becoming crystallographer.
- To explore the basics of x-ray diffraction and structure analysis.
- To understand basics of lattice dynamics and its related properties.
- To provide problem solving techniques.

B. Outline of the Course

Sr. No.	Title of Unit	No. of hrs.
1.	Crystal & Crystal structure forces responsible for the these structures	08
2.	X-ray diffraction and bonding of solids	07
3.	Lattice dynamics & their effects on thermal, acoustic and optical properties.	09
4.	Free electron theory & Drude model of electrical and thermal properties. Hall effect & thermoelectric power	06

A. **Syllabus Topics:** [1L + 1T]

Bravais lattice, Reciprocal lattice. Diffraction and structure factor, bonding of solids, elastic properties, phonon, lattice specific heat. Free electron theory and electronic specific heat, Relaxation phenomena, Drude model of electrical and thermal conductivity, Hall Effect and thermoelectric power

B . **Instructional Methods and Pedagogy:**

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Each lecture will follow with three questions, which will be answered in the class teaching. The problem solving sessions will be conducted during the tutorial session. Students will be trained as per JRF method of examination. Unit tests will be conducted regularly as a part of continuous evaluation and instruction will be provided to student in order to improve their performance.

C. Student Learning Outcomes / objectives:

- At the end of the course, student should be able to read scientific papers and articles describing crystal structure
- Ensuring that students acquire sound knowledge in analyzing crystal structure data for some basic crystals using X-ray.
- At the end students would gain experience in the problem solution which will help him to answer few JRF examination questions related to these topics.

D. Recommended Study Material:

Text books/Reference books

1. Crystals and Crystal structures: Richard Tilley, John Wiley & Sons, Ltd, 2006
2. C. Kittel, Introduction to Solid State Physics, Wiley India Pvt. Ltd., 2012.
3. M. Ali Omar, Elementary Solid State Physics, Pearson, 1st edition, 2008.
4. A J Dekker, Solid State Physics, McMillan India Ltd., 1st edition, 2008.
5. J. Ziman, Principles in the Theory of Solids, 2nd ed., Cambridge University Press, 1972.

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES

M.Sc. Physics (Semester-I)

PS 715 Computer programming

Credit: 3

A. Objective of the course.

- The objective of the course is to introduce students to computer programming.
- To explore students for logic development for writing various programs. This will be useful later for writing programs to solve scientific theories/equations.

B. Outline of the Course

Sr No.	Title of Unit	No. of hrs
1.	Elements of C-language	4h
2.	Simple C-programming	10h
3.	Control and loop structures	10h
4.	Arrays and functions	6h

A. Syllabus Topics [1L+2P]

Prerequisite

Introduction to computer, types of programming languages

Syllabus Topics

1. Elements of C Language
2. Simple C programs
3. Control structures
4. Loop structure
5. Arrays
6. Functions: User defined & library functions

B. Instructional Methods and Pedagogy:

The emphasis during Lecture sessions will be on Understanding of Concepts of computer programming. Stress is also given on relevant illustrations provided from the physics based numerical. Sufficient home assignments will be given to the students which will test their fundamentals and ability to relate concepts with reality.

C. Student Learning Outcomes / objectives:

- At the end of the program students will understand how to write basic programs using C-language.
- Higher order equations will be solved using numerical methods.
- Student will gain enough experience which will help them to write their own programs.

D. Recommended Study Material:

Reference Books:

1. C Language and Numerical Methods by C. Xavier, New Age International Publication
2. Programming with C, Byron Gottfried, Schaum's outlines, McGraw Hill Publications
3. Let Us C, Yashwant P Kanetkar, BPB Publications
4. C for Beginners, Madhusudan Mothe, Shroff pubshers
5. Programming in C, E Balagurusamy, Tata McGraw-Hill Education
6. Computer Oriented Numerical Methods, V. Rajaraman, PHI Learning Publisher
7. Numerical Methods with Programs in C & C++, T Veerarajan, T Ramachandran, Tata McGraw Hill

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc Physics (Semester-I)

PS 716 Practical I

Credit: 9

Objective of the course.

- The objective of the course is to make quantitative measurements to understand the basic electronic concepts.
- In this course, students will design, construct and analyze the electronics circuits to determine how various measured quantities affect the phenomenon and to establish a relationship between them, graphically or otherwise.

B. Outline of the Course

Sr No.	*Title of Unit*	No. of hrs
1.	General Physics and Basic electronic based experiments	12h/week

** List of the experiments will be decided based on the theory taught and student interest.*

A. **Syllabus Topics:** [12h/week]

I. Pre-lab Experiments

1. Study of Electronic components: Resistors, Capacitors, inductors, transformers, Transistors, diodes etc.
2. Breadboarding and Soldering of simple resistive circuits and d. c measurements. The purpose of this lab is to provide hands on experience in Breadboarding and Soldering of simple resistive circuits and d.c measurements
3. Introduction and operation of basic test instruments – I: dc power supplies , constant current sources and Multimeters
4. Introduction and operation of basic test instruments – II: Cathode Ray Oscilloscope (CRO) and signal generators. The purpose of this lab is to acquaint the use of an oscilloscope and function generator. Further to study how electrical measurement equipment measures dc, ac and composite waveforms and to become familiar with concepts relating to average, half-cycle average and root-mean-square values of waveforms.
5. Errors in Measurements. The objective is to study the non-ideal characteristics of electrical measurement equipment and to become familiar with concepts relating to error analysis and uncertainty.

II. Transistor Fundamentals (Biasing of a Bipolar Junction Transistor-BJT) and amplifiers

Objectives

1. Observe the effect of a changing base forward bias voltage on collector current and to recognize a shorted or open transistor using V_{CE} measurements.
2. Observe the variation of operating point for different biasing (Fixed bias and Self bias).
3. Design of voltage divider circuits and understand voltage divider bias for BJTs
4. Design a common emitter (single stage small-signal) amplifier and measure voltage gain.
5. Design a common collector amplifier (emitter follower) and measure the voltage gain.
6. Design of a Darlington amplifier, a class A Power amplifier and push –pull amplifier
7. Design of a Differential amplifier

III. General Physics based Experiments

1. Acousto-optical effect using piezo-electric crystal and determination of the velocity of ultrasonic wave in liquids and soilid.
2. Energy band gap of a semiconductor by four probe method.
3. Hall coefficient of a semiconductor.
4. Dielectric constant of ferroelectric material (Barium Titanate).
5. Study of physical properties of solids (specific heat, thermal expansion, thermal conductivity, dielectric constant).
6. To verify the existence of different harmonics and measure their relative amplitudes in complex wave (square, clipped sine wave, triangular wave etc.).
7. Characteristics of photo diode, photo transistor, LDR, LED.
8. Determination of k/e Using a Transistor.
9. Passive Filters.

M. Sc. (Physics) Programme

SYLLABI

(Semester – II)

CHAROTAR UNIVERSITY OF SCIENCE AND TECHNOLOGY

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc. Physics (Semester – II)

PS 717 Mathematical Methods in Physics – II

Credit: 2

A.Objective of the course.

- The objective of the course is to introduce students to various mathematical methods useful in physics.
- To explore the basics mathematical concepts.
- To provide problem solving techniques using these mathematical methods.

B. Outline of the Course

Sr. No.	Title of Unit	No. of hrs.
1.	Elements of complex analysis	10h
2.	Special Functions	10h
3.	Elementary idea about Tensors & Group Theory	10h

A. **Syllabus Topics:** **[1L + 1T]**

1. Elements of complex analysis [MLB –14]
2. Special Functions (Hermite, Bessel, Lagurre, Legendre) [MLB – 12]
3. Elementary idea about Tensors & Group Theory [MLB – 10]

B . Instructional Methods and Pedagogy:

The topics will be discussed in depth in an interactive class room environment using classical black–boardteaching method and also power–pointpresentations will be used at times. Some mathematical calculations will be visualized using computer programs in a full fledged computer laboratory. Brain storming sessions on various topics will be conducted in order to develop problem solving skills in the students. Students will be trained to crack national level examinations such as CSIR–JRF, GATE, DRDO, and BARC. Continuous evaluation process will be adopted by conducting small quizzes, class tests, and seminars which will provide the students an opportunity to improve on their performances.

C. Student Learning Outcomes / objectives:

- This course is aimed at providing students with the mathematical concepts and tools needed to understand crucial concepts of various branches of Physics.
- At the end of the course the students would be able to apply the mathematical methods to solve the problems of physics conceptually.
- The training that the student would gain will be useful in developing analytical and interpretation skills by correlating mathematical methods to various physics problems.
- At the long run the training provided will impact the students highly in qualifying the national level exams for further career.

D. Recommended Study Material:

Text books/Reference books

1. Mary L Boss [MLB], Mathematical Methods in Physical Sciences, 3rd Edition, John Wiley & Sons, India. {Text Book}.
2. Arfken& Weber, Mathematical Methods for Physicists (6^{th} edition), Elsevier, Academic Press (2012)

3. Erwin Kreyszig, Advanced Engineering Mathematics 8th Edition, Wiley India(p) Ltd.,
4. Dass H K, Mathematical Physics, S Chand and company 2004
5. P K Chattopadhyay, Mathematical Physics, New Age Iint. P. Ltd., Delhi, 2006.
6. H Margenu, Mathematical physics, East-West Press, 1962.
7. Mathematics of Classical and Quantum Physics – Byron, Fuller Dover (1992)
8. Mathematical Methods of Physics – Mathews & Walker – 2nd Edition- Pearson Edition
9. Mathematical Methods in Classical and Quantum Physics – Tulsi Das, S.K.Sharma, University Press India.
10. Mathematical Methods in Physics – Butkov Addition Wesley Publishers.
11. Mathematical Physics, by B.D. Gupta
12. Mathematical Physics, by Rajput.
13. Mathematical Methods for Physicists and Engineers, by K.F. Reily, M.P. Hobson and S.J. Bence
14. Complex variables and applications – J . W. Brown, R. V. Churchil, 7th Ed. Me–Graw Hill.
15. Complex variables – Seymour Lipschutz

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc. Physics (Semester-II)

PS 718Classical Mechanics-2

Credit: 3

A. Objective of the course.

- The objective of the course is to introduce students to advanced classical mechanics.
- To explore classical mechanics dynamical systems to solve the physics problems.
- This course also covers concepts of rigid body motion.

B. Outline of the Course

Sr. No.	Title of Unit	No. of hrs.
1.	Classical Mechanics Dynamical systems	6h
2.	Rigid body dynamics and pseudo forces	10h
2.	Poisson brackets and canonical transformations	5h
3.	Hamilton-Jacobi theory	6h
4.	Small oscillations	6h
5.	Special theory of relativity	5h

A. Syllabus Topics: [2 L + 1T]

1. Classical Mechanics Dynamical systems, Phase space dynamics, stability analysis.
2. Rigid body dynamics, moment of inertia tensor, Non-inertial frames and pseudo forces,
3. Poisson brackets and canonical transformations.
4. Symmetry, invariance and Noether's theorem.
5. Hamilton-Jacobi theory.
6. Periodic motion: small oscillations, normal modes.
7. Special theory of relativity, Lorentz transformations, relativistic kinematics and mass–energy equivalence.

B . Instructional Methods and Pedagogy:

The emphasis during Lecture sessions will be on Understanding of Concepts rather than on complexities subject. Stress is also given on relevant illustrations provided from the Real World processes. Sufficient home assignments will be given to the students which will test their fundamentals and ability to relate concepts with reality.

C. Student Learning Outcomes / objectives:

- Ensuring that students acquire sound knowledge in classical mechanics.
- At the end students would gain experience in the solving problems in classical mechanics.
- Major emphasis under this course is given on numerical solution, which will make them confident for JRF and any other competitive examinations.

D. Recommended Study Material:

Text books/Reference books

1. Classical Mechanics, H Goldstein, 2nd edition, Addison Wesley Publishing Company.
2. Classical Mechanics – N C Rana and P S Jog, Tata McGraw Hill, 1991
3. Classical Mechanics,- Yaswant Waghmere
4. Introduction Classical Mechanics - R. G. Takwale, P. S. Puranik, Tata McGraw Hill
5. Classical Mechanics – System of particles and Hamiltonian Dynamics' by Greiner, Springer International Ed. 2006
6. Classical Mechanics by G.Aruldhas, PHI

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc. Physics (Semester – II)

PS 719Quantum Mechanics – I

Credit: 2

A. Objective of the course.

The objective of the course is

- To introduce students to the physics of systems when their dimensions are microscopic.
- To make the students understand how classical physics cannot explain many of the physical phenomena.
- To understand the application of quantum mechanics to real life problems.

B. Outline of the Course

Sr. No.	Title of Unit	No. of hrs.
1.	Historical development of quantum mechanics	5h
2.	Mathematical tools for quantum mechanics	10h
3.	Postulates of quantum mechanics	6h
4.	Application of Schrodinger equation to 1D and 3D problems	6h

A. **Syllabus Topics:** [1L + 1T]

1. Historical development of quantum mechanics [LIS – 1]
2. Mathematical tools for quantum mechanics [RS – 1]
3. Postulates of quantum mechanics [RLL – 3]
4. Application of Schrodinger equation to 1D and 3D problems [RLL – 7,8]

B . Instructional Methods and Pedagogy:

The topics will be discussed in depth in an interactive class room environment using classical black–boardteaching method and also power–pointpresentations will be used at times. Some mathematical calculations will be visualized using computer programs in a full fledged computer laboratory. Brain storming sessions on various topics will be conducted in order to develop problem solving skills in the students. Students will be trained to crack national level examinations such as CSIR–JRF, GATE, DRDO, and BARC. Continuous.

C. Student Learning Outcomes / objectives:

- This course is aimed at providing students the understanding of limitation of classical physics at some point.
- At the end of the course the student would understand the abstract behavior of nature in the quantum world.
- They would be able to apply the postulates of quantum mechanics to solve various physics problems.

D. Recommended Study Material:

Text books/Reference books

1. Introductory Quantum Mechanics – Richard L. Liboff, Addision – Wesley
2. Principles of Quantum Mechanics – R. Shankar, Plenum Publishers 2nd edition
3. Quantum Mechanics – Leonard I. Schiff, McGraw Hill, Third edition

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc. Physics (Semester – II)

PS 720Electromagnetic Theory – I

Credit: 2

A. Objective of the course.

The objective of the course is

- To introduce student to the concepts of charge in static state and what happen ehn charge moves.
- To make the students understand how the laws of physics work for charged particles and matter in electric field.
- To develop the skill of solving complex problems using various techniques.

B. Outline of the Course

Sr. No.	Title of Unit	No. of hrs.
1.	Electrostatics	8h
2.	Special Techniques	8h
3.	Electric Fields in matter	8h
4.	Magnetostatics	8h

A. **Syllabus Topics:** [IL + IT]

1. Electrostatics [Griffiths – 2]
2. Special Techniques [Griffiths – 3]
3. Electric Fields in matter [Griffiths – 4]
4. Magnetostatics [Griffiths – 5]

B . Instructional Methods and Pedagogy:

The topics will be discussed in depth in an interactive class room environment using classical black-boardteaching method and also power-pointpresentations will be used at times. Some mathematical calculations will be visualized using computer programs in a full fledged computer laboratory. Brain storming sessions on various topics will be conducted in order to develop problem solving skills in the students. Students will be trained to crack national level examinations such as CSIR-JRF, GATE, DRDO, and BARC. Continuous

C. Student Learning Outcomes / objectives:

- At the end of the course students will understand electrostatics and magnetostics phenomena, which are useful for elecrodynamics.
- Numerical solutions are the key factors which students will learn through this course.

D. Recommended Study Material:

Text books/Reference books

1. Introduction to Electrodynamics, David J. Griffiths, PHI publication, 3rd edition,1999.
2. Classical Electrodynamics, John David Jackson, John Wiley & Sons, Inc., 3rd edition, 1998.
3. Elements of Engineering Electromagnetics, Narayana Rao, N., Prentice-Hall of India 5th Ed., 2002
4. Classical electromagnetic Theory by Jack Vanderlinde, John Wiley & sons, Inc.1993.
5. Elements of Electromagnetics by Sadiku 2ndEd.Oxford Univ.Press. Inc. 1995
6. Classical Electrodynamics by Greiner, Springer Verlag, New York, Inc. 1998
7. Introduction to Electrodynamics, by A.Z.Capri and P.V.Panat, Narosa Publishing House
8. Classical electricity & Magnetism, by panofsky and Phillips, Addison Wesley
9. Foundations of Electromagnetic theory, by Reitz & Milford, World student series Edition.
10. Electromagnetic theory and Electrodynamics, by SatyaPrakash, KedarNath and co. Meerut.
11. Special theory of Relativity by Robert Resnick.
12. Electromagnetics by B.B.Laud, Willey Eastern

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc. Physics (Semester-II)

PS 721 Electronics

Credit: 3

A. The objective of the course is to:

- *Discuss operational amplifiers and their applications.*
- *Describe the characteristics of a digital electronic system and digital electronic gate circuits.*
- *Discuss how counting, decoding, multiplexing, demultiplexing, and clocks function with logic devices.*
- *Identify some of the common functions of digital memory and to explain how arithmetic operations are achieved with digital circuitry.*
- *This course also covers concepts of microprocessor*

B. outline of the Course

Sr No.	***Title of Unit***	No. of hrs
1.	Operational amplifiers and their applications	10h
2.	555 Timer circuits & Voltage regulator ICs and their applications	5h
3.	Digital ICs ,Combinational logic gates & Sequential logic gates	8h
4.	Counters, shift registers , Data Conversion	6h
5.	Introduction to microprocessor system	12h

A. Detailed syllabus **[2L+1T]**

OP-AMP: IC 741 circuits - amplifiers, scalar, summer, subtractor, comparator, logarithmic amplifiers, Active filters, differentiator, integrator, wave shapers, and oscillators. Schmitt trigger; 555 Timer: Astable, monostable and bistable multivibrators, Voltage regulator ICs; Logic gates; Logic Families: TTL, MOS and CMOS; Boolean algebra; De-Morgan's theorem; Combinational Circuits: Adders, subtractors, Encoder, De-coder, Comparator, Multiplexer, De-multiplexers, Sequential Circuits: Flip-flops, Registers, Counters, Memories; A/D and D/A conversion. Introduction to Microprocessor 8085.

B. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching and ICT. Topic related tutorial questions will be given in advance and sample questions will be discussed during the lectures and other questions will be discussed during the tutorial sessions. Students will be trained as per JRF method of examination by giving topic wise MCQ and numerical questions. Unit tests will be conducted regularly as a part of continuous evaluation and instruction will be provided to the student in order to improve their performance.

C. Student Learning Outcomes / objectives:

- At the end of the program students will have basic training in designing the digital circuits as per the specification provided.
- Ensuring that students acquire problem solving in digital and analog circuits required for the competitive exams like GATE, NET/JRF.
- Student will gain enough experience which will help them to understand course on advance electronics.

D. Recommended Study Material:

1. Integrated Electronics by Milman and Halkias
2. Electronics principles by Albert Malvino, Carrier Education publishers
3. Electronics Fundamentals and Applications by John D. Ryder
4. Fundamental of Electronics Devices by Milman and Halkias
5. Digital Principles and Application by Malvino and Leach
6. Digital Logic and Computer Design by M. Morris Malvino
7. Modern Digital Electronics by R. P. Jain; TataMcGraw Hill, New Delhi
8. Integrated Electronics by K. R. Botkar.
9. Electronic Devices & Components by J. Seymour.
10. Basic Electronics by Paul E. Zobar.
11. Elements of Microwave a Test Lab Manual by Rajeswari Chatterjee
12. Ramakant A.Gayakward- Op-Amps and linear integrated circuits-Pearson Education.
13. Ramesh Goankar- Microprocessor Architecture, Programming and application with the 8085-Penram International Publishing Company.

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc Physics (Semester-II)

PS 722 Practical- II

Credit: 10

A. Objective of the course.

- The objective of the course is to make quantitative measurements to understand the basic digital electronic concepts.
- In this course, students will design, construct and analyze the circuits of basic digital electronics .

B. Outline of the Course

Sr No.	Title of Unit	No. of hrs
1.	Practical Measurement of Op-amp Parameters and opamp applications, Circuits using 555 – Timer, IC regulators, Combinational & Sequential logic circuits, Converters, Familiarization of Microprocessor (8085).	12 h/week

* List of the experiments will be decided based on the theory taught and student interest.

A. Syllabus Topics: [12h/week]

I. Pre-lab Experiments

1. Practical Measurement of Op-amp Parameters
2. Build simple logic circuits using digital ICs and to see the Universality of NAND / NOR gates.
3. Solving Boolean Expressions using digital ICs.

II. IC 741 Operational Amplifiers applications, Circuits using 555 – Timer and voltage regulator ICs based experiments

Objectives

1. Design, construct and study Inverting, Non-Inverting and buffer amplifier using 741 Op-amp
2. Design, construct and study Op amp adder and subtractor circuit.
3. Design, construct and study the frequency response of Active Butterworth filters
4. Design and construct Differentiator and Integrator circuit using op amp 741.
5. Design and construct Op amp741Square wave and Triangular wave Generator.
6. Design and construct Schmitt Trigger Circuits using IC 741.
7. Design and construct Precision Rectifier and Logarithmic converters.
8. IC 555 timer-Astable and Monostable multivibrators
9. Regulated power supply using IC LM 317/ IC723

III. Digital ICs -Combinational & Sequential logic circuits, Registers and cnvertes

Objectives

1. Design and study the performance of half – adder and full – adder using logic gates.
2. Design and study the action of RS, JK and D flip flops circuits using logic gates and study their performance.
3. Design and study of various counter circuits (up, down, ring, mod-n) and registers.
4. Study the performance of D/A converter- Binary weighted resistors and R-2R ladder network

IV. Microprocessor (8085)

Objectives

1. Store 8 bit data in the memory
2. Exchange the content of memory locations
3. Addition of Two 8-bit Numbers and Sum is 8-bit and 16-bit.
4. Addition of Two 16-Bit Numbers and Sum is 16-bit
5. Subtract two 8 bit numbers
6. Decimal Addition of Two 8-Bit Numbers and Sum is 8-bit
7. One's Complement of an 8-bit Number
8. Two's Complement of an 8-bit Number

M. Sc. (Physics) Programme

SYLLABI

(Semester – III)

CHAROTAR UNIVERSITY OF SCIENCE AND TECHNOLOGY

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc. Physics (Semester – III)

PS 901 Electromagnetic Theory – II

Credit: 2

C. Objective of the course

- The objective of the course is to introduce students to electrostatic and magnetic theory
- This course also covers concepts of electromagnetism and electrodynamics.
- The emphasis is given for problem solving techniques.

D. Outline of the Course

Sr. No.	Title of Unit	No. of hrs
1.	Magnetic Field in matters	10h
2.	Electrodynamics	10h
3.	Electromagnetic waves	10h

A. **Syllabus Topics:** **[1L + 1T]**

1. Magnetic fields in matters: Magnetization, field of magnetized bodies, Auxiliary field, linear and nonlinear media. (Chap. 6, Griffith)
2. Electrodynamics: Electromotive forces, Induction, Maxwell's equations. (Chap. 7, Griffith)
3. Electromagnetic waves: Waves in one dimension, electromagnetic waves in vacuum, EM waves in matter, Absorption and dispersion, Wave guides (Chap. 9, Griffith)

B . Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in the laboratory. Special interactive problem solving sessions will be conducted by respective faculty members on weekly bases during the tutorial session. Students will be trained as per JRF method of examination. Unit tests and assignments will be conducted regularly as a part of continuous evaluation and instruction will be provided to student in order to improve their performance.

C. Student Learning Outcomes / objectives:

- At the end of the program students will understand magnetic field interaction and potential which are useful in electrodynamics.
- Numerical solutions are the key factors which student will learn through this course.
- Student will gain enough experience which will help them to understand course on advance electrodynamics.
- At the end students would gain experience in the problem solution which will help him to clear JRF examination.

D. Recommended Study Material:

Text books/Reference books

1. Introduction to Electrodynamics, David J. Griffiths, PHI publication, 3rd edition, 1999.
2. Classical Electrodynamics, John David Jackson, John Wiley & Sons, Inc., 3rd edition, 1998.
3. Elements of Engineering Electromagnetics, Narayana Rao, N., Prentice-Hall of India 5th Ed., 2002
4. Engineering Electromagnetics: Hayat & Buck, Mc-Graw Hill.
5. Elements of Electromagnetics, Matthew N. O. Sadiku

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc. Physics (Semester – III)

PS 902 Quantum Mechanics – II

Credit: 2

A. Objective of the course

The objective of the course is

- To introduce students to the physics of systems when their dimensions are microscopic.
- To make the students understand how classical physics cannot explain many of the physical phenomena.
- To understand the application of quantum mechanics to real life problems.

B. Outline of the Course

Sr. No.	Title of Unit	No. of hrs
1.	Perturbation theory and variation method	8h
2.	Angular momentum and Spin	8h
3.	Scattering theory	8h
4.	Dirac Equation and Introductory Relativistic Quantum Mechanics	6h

A. **Syllabus Topics:** **[1L + 1T]**

1. Perturbation theory and variation method [RLL – 13]
2. Angular momentum and rotation [RLL – 9,11]
3. Radiation and Scattering theory [RLL –14]
4. Dirac Equation and Introductory Relativistic Quantum Mechanics [RS – 20]

B . Instructional Methods and Pedagogy:

The topics will be discussed in depth in an interactive class room environment using classical black–board teaching method and also power–point presentations will be used at times. Some mathematical calculations will be visualized using computer programs in a full fledged computer laboratory. Brain storming sessions on various topics will be conducted in order to develop problem solving skills in the students. Students will be trained to crack national level examinations such as CSIR–JRF, GATE, DRDO, and BARC. Continuous

C. Student Learning Outcomes / objectives:

- This course is aimed at providing students the understanding of limitation of classical physics at some point.
- At the end of the course the student would understand the abstract behavior of nature in the quantum world.
- They would be able to apply the postulates of quantum mechanics to solve various physics problems.

D. Recommended Study Material:

Text books/Reference books

1. Introductory Quantum Mechanics – Richard L. Liboff, Addision – Wesley
2. Principles of Quantum Mechanics – R. Shankar, Plenum Publishers 2nd edition
3. Quantum Mechanics – Leonard I. Schiff, McGraw Hill, Third edition

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc Physics (Semester-III)

PS 903 Analytical Techniques

Credit: 3

C. Objective of the course.

- The objective of the course is to introduce students to different types of experimental techniques available.
- This course will expose student to state of art equipments and their utility.
- The emphasis is given more on analyzing of the data and operating skills.

C. Outline of the Course

Sr. No.	Title of Unit	No. of hrs
1.	Structural characterization-I	10h
2.	Structural characterization-II	10h
3.	Optical spectroscopy	6h
4.	Magnetic characterizations techniques	6h

A. Syllabus Topics: **[1L +1T + 2P]**

1 Structural characterization-I
X-ray diffraction: Powder diffraction basics, lattice parameter calculation, particle size determination, structural identification, Introduction to small angle scattering techniques (X-ray & Neutron), Examples.
2 Structural characterization-II
Basic concepts of Scanning electron microscopy, Transmission electron microscopy, size and size distribution methods, Concept of Dynamic light scattering and basics of Particle size analyzer, AFM, Examples.
3 Optical spectroscopy:
UV-visible spectroscopy, PL, FTIR, Brief introduction of Raman Spectroscopy
4 Magnetic characterizations techniques
5 Magnetic characterization (SQUID, VSM, Ac-susceptometer)

B . Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be performed and analyzed by students individually.Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.
Visit to scientific labs of national repute to give insight to the subject will be provided. The visit report will be counted in the internal assessment either through submission or seminar/viva.

C. Student Learning Outcomes / objectives:

- The Programme aims at providing students with the methodological concepts and tools needed to acquire top-level skills in the field of instrumentation
- Ensuring that students acquire sound knowledge base for future research.
- At the end students would gain experience in using these tools and analyzing the data.

D. Recommended Study Material:

Text books/Reference books

1. X-ray Diffraction, A practical Approach by C suryanarayana & M Grant Norton, Plenum Press, New York, 1998.
2. Elements of X-ray diffraction by B D Cullity, Addision Wesley, 1956.
3. Instrumental methods of analysis by Williard Merritt Dean Settle, 7th Ed. CBS publishers and distributors Pvt. Ltd.,
4. Transmission electron microscopy A textbook for material science, by David Williams and C Barry Carter, Vol. 1-4 Springer
5. Nanostructures & Nanomaterials: Synthesis, Properties and applications, Guozhong Cao, Imperial College Press. 2007.
6. Introduction to magnetic materials by B D Cullity & C D Graham, Addision Wesley.

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc Physics (Semester – III)

PS 904 Numerical Analysis

Credit: 3

A. Objective of the course.

The objective of the course is

a. To introduce students to the various numerical methods available to solve various mathematical and physical problems
b. To provide a platform to solve problems numerically and employing computer programs
c. To make the students understand how numerical methods can be handy and useful to tackle difficult problems.

B. Outline of the Course

Sr. No.	Title of Unit	No. of hrs
1.	Errors in numerical methods	5hr
2.	Finding roots of equations	8hr
3.	Curve fitting	8hr
4.	Numerical differentiation and integration	5hr
5.	Ordinary differential equations	3hr

A. **Syllabus Topics:** **[1L +1T+2P]**

1. Errors in numerical methods: significant figures, accuracy and precision, error definitions, round –off errors, truncation errors and Taylor series, error propagation, total numerical error [CHAPRA – 3,4]
2. Finding roots of equations: Bisection method, false-position method, simple fixed point iteration, Newton-Raphson method, Secant method, multiple roots, Muller's method, Bairstow's method.[CHAPRA –5,6,7]
3. Curve fitting: Linear regression, linear least squares, nonlinear regression, interpolation methods: Newton's divided difference methods, Lagrange interpolation, spline interpolation.[CHAPRA –454,488]
4. Numerical differentiation and integration: Newton-Cotes integration formulas: the trapezoidal rule, Simpson's rules, integration with unequal segments, Newton-Cotes algorithms for equations, Romberg integration, adaptive quadrature, Guass quadrature, Richardson extrapolation, [CHAPRA – 631,653]
5. Ordinary differential equation: Euler's method, improvements of Euler's method, Runge – Kutta methods. [CHAPRA – 707]

B. **Instructional Methods and Pedagogy:**

The topics will be discussed in depth in an interactive class room environment using classical black–board teaching method and also power–point presentations will be used at times. Some mathematical calculations will be visualized using computer programs in a full fledged computer laboratory. Brain storming sessions on various topics will be conducted in order to develop problem solving skills in the students. Students will be trained to crack national level examinations such as CSIR–JRF, GATE, DRDO, and BARC.

C. **Student Learning Outcomes / objectives:**

- This course is aimed at providing students the understanding of various numerical methods to solve tricky mathematical problems.
- At the end of the course the student would be able to apply the numerical methods and design their own algorithm for solving problems

D. **Recommended Study Material:**

Text books/Reference books

1. Numerical methods for engineers, Chapra and Canale, McGrawHill, 6th edition
2. Introductory methods for numerical analysis, S S Sastry, 5th edition

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc Physics (Semester-III)

PS 905 Atomic Physics

Credit: 2

A. Objective of the course.

- The objective of the course is to introduce students to Atomic physics, which is principal component of the so called Modern Physics.
- To understand the historical development of atomic theories along with the quantum mechanics, uniqueness of atomic spectra and its scientific and technological applications.
- To solve problems related to the atomic models.

B. Outline of the Course

Sr No.	Title of topics	Minimum No. of hrs
1.	General Atomic Spectroscopy	10h
2.	Coupling effects of magnetic and electric fields	11h

A. **Syllabus Topics:** **[1L + 1T]**

1. General Atomic Spectroscopy: Quantum state of an electron atom, Electron spin, Spectrum of Helium and Alkali atoms, Dirac equation, Relativistic correction for energy levels of hydrogen atoms. Hyperfine structure and isotropic shift, Width of spectral lines.
2. Coupling effects of magnetic and electric fields: L-S & J-J couplings, Zeeman, Paschen-Back and Stark Effects.

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B. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in the laboratory. Special interactive problem solving sessions will be conducted by respective faculty members on weekly bases during the tutorial session. Students will be trained as per JRF method of examination. Unit tests and assignments will be conducted regularly as a part of continuous evaluation and instruction will be provided to student in order to improve their performance.

C. Student Learning Outcomes / objectives:

- The Program aims at providing students with the methodological concepts and tools needed to acquire understanding in spectroscopy with reference to atomic and molecular spectroscopy.

- At the end students would gain experience in the problem solution which will help him to clear JRF examination.

D. Recommended Study Material:

1. Atomic and Molecular Spectra: Laser – by Raj Kumar (Kedar Nath Ram Nath publications)
2. Physics of Atoms and Molecules – by B. Bransden and C. J. Joachain (Pearson Education Publication (New Delhi)
3. Elements of spectroscopy – by Gupta, Kumar and Sharma (PragatiPrakashan Meerut)
4. Spectroscopy (Atomic and molecular) by G. Chatwal and S. Anand.
5. Spectroscopy, Barrow

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc Physics (Semester-III)

PS 906 Practical III

Credit: 11
Hours /week: 12

List of Experiments

1 The following experiments may be performed with the help of this setup (Lattice Dynamic)
   (i) Study of the dispersion relation for the mono-atomic lattice-Comparison with theory.
   (ii) Determination of the cut-off frequency of the mono-atomic lattice.
   (iii) Study of the dispersion relation for the di-atomic lattice – 'acoustical mode' and 'optical mode' energy gap. Comparison with theory.
2 Determination of Energy Band Gap of Silicon, Germanium etc using diodes and light emitting diodes.
3 Frank and Hertz to verify following considerations.
   (i) It is possible to excite atoms by low energy electron bombardment.
   (ii) The energy transferred from electrons to the atoms always had discrete values.
   (iii) The values so obtained for the energy levels were in agreement with spectroscopic results.

   Thus the existence of atomic energy levels put forward by Bohr can be proved directly.
4 Zeeman Effect – To understand the concept of space quantization through splitting of spectral lines of atoms under the external magnetic field.
5 Electron Spin Resonance – To study Zeeman interaction of the magnetic dipoles associated with the electron, when placed in an external magnetic field.
6 To verify the Hartmann Dispersion Formula and to determine the dissociation energy of Iodine (I_2) molecule using a constant deviation spectrometer
7 Quinck's experiment – To study magnetic susceptibility of paramagnetic and superparamagnetic liquids.
8 Michelson Interferometer - Introduction to Interferometry, Measuring wavelength of light, Measuring refractive index of air, and Measuring refractive index of material or substance
9 Determination of dielectric constant of non aqueous liquid at different concentration and hence determination of Dipole Moment (e.g. of Nitrobenzene etc.)
10 Determination of viscosity of liquid using capillary viscometer
11 Workshop

**Final list of the experiments will be decided based on the theory taught and student interest.*

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc. Physics (Semester-III)
PS 907 Thin Film Technology
(Elective)

Credit: 2

A. Objective of the course.

- The objective of the course is to impart knowledge of advanced Thin Film Technology.
- To give information regarding different techniques of thin film deposition along with applications
- To make aware of the emerging technologies in thin film deposition

B. Outline of the Course

Sr No.	Title of Unit	No. of hrs
1.	Growth and types of thin films	3
2.	Physical vapour deposition	4
3.	Chemical vapor deposition	2
4.	Solution-based deposition	4
5.	Characterization of thin films	4
6.	Applications of thin films	3

A. Syllabus Topics: [1L+1T]

Growth and types of thin films:
Basics of thin films, nucleation and growth, capillarity theory, atomistic and kinetic models of nucleation, stages of film growth and mechanisms, structure, epitaxy, types of thin films, metal, semiconductor and insulator

Physical vapor deposition:
Vacuum systems, vacuum gauges, Hertz Knudsen equation; mass evaporation rate; Knudsen cell, Directional distribution of evaporating species Evaporation of elements, compounds, alloys, Raoult's law; e-beam, pulsed laser and ion beam evaporation, reactive evaporation, Glow Discharge and Plasma, Sputtering– mechanisms and yield, dc and rf sputtering, Bias sputtering, magnetically enhanced sputtering systems, reactive sputtering

Chemical Vapor deposition:
Reaction chemistry and thermodynamics of CVD; Thermal CVD, plasma enhanced CVD for amorphous silicon thin films,

Solution based deposition:
Electrochemical deposition, dip-coating, spin-coating, chemical bath deposition, direct liquid coating, spray pyrolysis, sol gel technique, ink-jet material printing.

Characterization of thin films:
X-ray diffraction, Scanning Electron Microscopy, Atomic Force Microscopy, optical properties,

Applications of thin films:
Photodetectors, protective coatings, solar cells, optical coatings, decorative coatings, batteries,

B. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class-room sessions using classical black-board teaching to power-point presentations. Practical sessions may be conducted in the laboratory. Respective faculty members on weekly basis will conduct special interactive problem solving sessions during the tutorial session. Wherever possible the emphasis will be on 'hands-on' experiments for the conceptual understanding of device operation. Unit tests and assignments will be conducted regularly as a part of continuous evaluation and instruction will be provided to student in order to improve their performance.
Visit to scientific labs of national repute will be provided to give insight to the subject. The visit report will be counted in the internal assessment either through submission or seminar/viva.

C. Student Learning Outcomes / objectives:

- The student should after the course be able to describe the basic principles behind deposition of different types of thin films

- Other objectives are that the student will know which deposition technique is appropriate from point of view of applied research or industrial R&D
- During this course, students will do experiments to enhance their conceptual understanding.

D. Recommended Study Material:

Text books/Reference books

1. Thin Film Fundamentals by A. Goswami
2. Handbook of Deposition Technologies for Films and Coatings by P. M. Martin (Editor)
3. Solution Processing of Inorganic Materials Edited by David Mitzi
4. Materials Science of Thin Films by M. Ohring

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc. Physics (Semester-III)
PS 908 Physics of Solar Cells
(Elective)

Credit: 2

A. Objective of the course.

- The objective of the course is to impart understanding of basic physics of solar cells: photovoltaic effect and its use to design solar cells
- To give information regarding different types of commercial and non-commercial solar cells

B. Outline of the Course

Sr No.	Title of Unit	No. of hrs
1.	Importance of Solar Energy	2
2.	p-n junction as solar cells	4
3.	Design of solar cell	3
4.	Monocrystalline silicon solar cell	3
5.	Thin film solar cells	3
6.	Emerging solar cells	3

A. Syllabus Topics: [1L-1T]

1. Importance of Solar Energy
   Energy scenario, Need for sustainable energy, Renewable Energy sources, Role of Solar Energy, Sun as a energy resource, Solar Radiation: Extra terrestrial and terrestrial radiations, instruments to measure solar radiation, solar radiation geometry, hourly, daily and seasonal variation of insolation,solar radiation on horizontal and tilted surfaces
2. P-N Junction as solar cells
   Space charge region, Energy band diagram, P-N junction potential and depletion region, Carrier Movements and concentration profiles, P-N junction in Non-equilibrium condition, P-N junction under illumination, photovoltaic effect, generation and recombination of carriers, light generated current, I-V equations and characteristics of solar cell
3. Design of solar cell
   Upper limit of solar cell parameters, Losses in solar cells, Design for High I_{sc}, Design for High V_{oc}, Design for FF, I-V and QE measurements, Minority carrier life time and diffusion length measurements
4. Monocrystalline silicon (Si) solar cell
   Production of Metallurgical and electronics Grade Si, Production of Monocrystalline Si, Processes for fabrication of Monocrystalline Si, High efficiency Si solar cells
5. Thin film solar cells
   Advantage of Thin Film technology, Materials for Thin film Technology, Features of Thin film Technology, Thin film Deposition techniques, Cadmium Telluride (CdTe) solar cells, Chalcopyrite (CIS/CIGS) solar cells, Polycrystalline Si solar cells
6. Emerging solar cells
   Organic/polymer solar cells, Dye-sensitized solar cells (DSC), Quantum dot solar cells (QDSCs), CZTS solar cells

B. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class-room sessions using classical black-board teaching to power-point presentations. Practical sessions may be conducted in the laboratory. Respective faculty members on weekly basis will conduct special interactive problem solving sessions during the tutorial session. Wherever possible the emphasis will be on 'hands-on' experiments for the conceptual understanding of device operation. Unit tests and assignments will be conducted regularly as a part of continuous evaluation and instruction will be provided to student in order to improve their performance.

C. Student Learning Outcomes / objectives:

- The student should after the course be able to describe the basic principles of solar cells and design
- The students will be have knowledge of different types of solar cells available commercially and in laboratory thus stimulating them for research.
- During this course, students will do basic experiments to enhance their conceptual understanding.

D. Recommended Study Material:

Text books/Reference books

1. The Physics of Solar Cells by Jenny Nelson (Imperial College Press, 2013)
2. Physics of Solar Cells by Peter Wurfel
3. Solar Photovoltaics: Fundamentals, Technologies and Applications by Chetan Solanki
4. Thin film Solar Cells by K. L. Chopra and S. R. Das

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc. Physics (Semester-III)
PS 909 Introduction to Nanotechnology
(Elective)

Credit: 2

A. Objective of the course.

The course content has been structured to help the student achieve the following objectives:

1. To gain an understanding of the principles of nanotechnology, characterization of nano-structured materials, and tools and equipment for producing and assembling at the nano scale.
2. To acquire practical experience in the use of equipment used in nanotechnology.
3. To cultivate interest in the research and development of nanotechnology for future advancement of the career.

B. Out line of the Course

Sr No.	*Title of Unit*	*No. of hrs*
1.	Nanotechnology – development history	*3h*
2.	Overview on characterization and synthesis of nanostructure materials	*10h*
3.	Overview of nanostructures	*6h*
4.	Nanodevices	*4h*
5.	New fields of nanotechnology	*4h*
6.	Implications of nanotechnology	*3h*

A. Syllabus Topics: [1L+1T]

1. Nanotechnology – development history [JR-1-3]
2. Overview on characterization and synthesis of nanostructure materials. [JR-4,7]
3. Overview of nanostructures [JR-5]
4. Nanodevices [JR-6]
5. New fields of nanotechnology [JR-9]
6. Implications of nanotechnology [JR-10]

B. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Students will be exposed to practical operations, and experimental demonstrations of some of the equipment for Nano fabrication available in UNI. Students will produce a technical report on the experiences.

C. Student Learning Outcomes / objectives:

- Nanotechnology promises to be the technology of the future benefitting the humanity in a number of ways. This course is aimed at preparing students for further industrial or academic work in the field of nano-characterization techniques.

D. Course Pre-requisites

PS 707 Analytical techniques

E. Recommended Study Material:

Text Books:

Essentials of nanotechnology by Jeremy Ramsden [JR], 2009, Jeremy Ramsden & Ventus Publishing ApS, (download from http://bookboon.com/en/nano-technology-ebook)

Reference Books:

1. *Introduction to Nanoscience*, S.M.Lindsay, Oxford ISBN 978-019-954421-9 (2010).
2. Guozhong Cao (2004). *Nanostructures and Nanomaterials: Synthesis, Properties & Applications*, 448 pages, Imperial College Press, ISBN-10:1860944159

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc. Physics (Semester-III)
PS 910 Nanomaterials: synthesis and properties
(Elective)

Credit: 2

A. Objective of the course.

The course content has been structured to help the student achieve the following objectives:

1. To gain an understanding of various aspects of synthesis of Nanomaterials, and effect of size reduction on different properties, viz. mechanical, structural, electrical, optical, etc., of Nanomaterials.
2. To acquire practical experience in the use of equipment used in nanotechnology.
3. To cultivate interest in the research and development of nanotechnology for future advancement of the career.

B. Outline of the Course

Sr No.	*Title of Unit*	*No. of hrs*
1.	*Synthesis of Nanomaterials-I (Physical Methods)*	*8 h*
2.	*Synthesis of Nanomaterials-II (Chemical Methods)*	*7 h*
3.	*Synthesis of Nanomaterials-III (Biological Methods)*	*7 h*
4.	*Properties of Nanomaterials*	*8 h*

A. Syllabus Topics: [1L+1T]

1. Synthesis of Nanomaterials-I (Physical Methods) [SK-3]
2. Synthesis of Nanomaterials-II (Chemical Methods) [SK-4]
3. Synthesis of Nanomaterials-III (Biological Methods) [SK-5]
4. Properties of Nanomaterials [SK-7]

B. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Students will be exposed to practical operations, and experimental demonstrations to synthesize Nanomaterials using different routes. Also students will be exposed to measure characterize the Nanomaterials using various measurement techniques available in UNI. Students will produce a technical report on the experiences.

C. Student Learning Outcomes / objectives:

- Nanotechnology promises to be the technology of the future benefitting the humanity in a number of ways. This course is aimed at preparing students for further industrial or academic work in the field of Nanoscience and technology.

D. Course Pre-requisites

Basic knowledge of crystal strcture/crystallography
Basic knowledge of quantum mechanics

E. Recommended Study Material:

Text Books:

Nanotechnology: Principles and practices, Sulabha K Kulkarni, Capital publishing company, 2007.

Reference Books:

3. Guozhong Cao (2004). *Nanostructures and Nanomaterials: Synthesis, Properties & Applications*, 448 pages, Imperial College Press, ISBN-10:1860944159
4. *Introduction to Nanoscience*, S.M.Lindsay, Oxford ISBN 978-019-954421-9 (2010).
5. Nanocrystalline Materials, A.I. Gusev, A.A. Rempel, Cambridge International Science Publishing, (2003)

Possible experiments:

Demonstrative experiments

(1) Synthesis of nanoparticles (e.g. ZnO, CdSe, CdS, etc.)
(2) Synthesis of magnetic nanoparticles (e.g. ferrite or metal nanoparticles)

Experiments to be performed

(1) Structure determination using powder x-ray diffractometer.
(2) Particle size determination using particle size analyzer.
(3) Magnetic properties measurement of magnetic nanoparticles.
(4) Energy band-gap determination of thin-film.

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc. Physics (Semester-III)
PS 911 Nanofluidics
(Elective)

Credit: 2

A. *Objective of the course.*

- The objective of the course is to give an introductory knowledge of nanofluidics (fundamental aspects, intrinsic length scales where surface and interface effects dominate the dynamics and geometry).
- The students will gain insight into the forces and physical mechanisms that determine and are available for transport at micro- and nanoscales.
- To explore the different selected topics such as: solid-liquid interfaces, hydrodynamics at small scales, 3-phase systems, electrokinetic, electrophoresis, separation techniques and colloids in the field of nanofluidics.
- The course provide students with a basis for estimating quantities such as stresses exerted by liquids on microscopic objects, flow velocities and mixing efficiencies.
- These skills will facilitate the identification of the best-suited transport mechanism for a specific system in the context of fundamental research or industrial R&D.

B. Outline of the Course

Sr No.	Title of Unit	No. of hrs
1.	Introduction Nanofluidics	3h
2.	Nanofluidic Manipulation Principle	6h
3.	Fluid Surface Interaction for Nanofluidics	6h
4.	Applications of Nanofluidics	5h

A. Syllabus Topics: *[1L+1L]*

1. Length scales: Macroscopic fluid properties, transition from the molecular to the continuum picture, Relative importance inertia, surface tension, gravity and viscous forces.
2. The predominance of viscous friction and interfacial effects: - The Stokes equation and corresponding boundary conditions, Physical Background of Downscaling effects, Structure related effects, Manipulation Principles i.e. Electroosmosis, Electrowetting, Fluid
3. Surface forces: - Liquids in contact with other phases: surface tension, Van der Waals & Casimir forces, contact angles, superhydrophobic surfaces, Surface-Interaction: Adoption, Interaction in double layer, Surface-interaction, interface,
4. Applications: - Transport in porous media - Biological systems, lipid membranes and vesicles, concepts of Microchannel, Singularly addressable nanochannels: Top-down approach, Bottom up approach, Ensembles of nanofluidics channels as selective interconnection.

B. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class-room sessions using classical black-board teaching to power-point presentations. Practical sessions may be conducted in the laboratory. Respective faculty members on weekly basis will conduct special interactive problem solving sessions during the tutorial session. Students will be trained for the advance level understanding of fluid dynamics. Unit tests and assignments will be conducted regularly as a part of continuous evaluation. Instruction will be provided to student in order to improve their performance.

C. Student Learning Outcomes / objectives:

- The Program aims at providing students with the methodological concepts and tools needed to acquire top-level skills in the field of fluid dynamics.
- Ensuring that students acquire sound knowledge base for future research in soft condensed matter Physics as well as for students who wish to work in interdisciplinary area.
- During this course, students will do experiments to enhance their conceptual understanding.

D. Recommended Study Material:

Reference Books

i. *Encyclopedia of Nanoscience & Nanotechnology Vol. 6 by H S Nalwa, American Scientific* Publication. Pg. 739-774.

ii. Nanoparticle Technology Handbook Edited by Masuo Hosokawa, Kiyoshi Nogi, Makio Naito, Toyokazu Yokoyama. Elsevier Science Publication. Chapter 3

iii. Nanofluids Properties And Their Applications, Debendra Das Devdatta Kulkarni LAP Lambert Academic Publishing, 2012.

iv. Nanofluidics: 1st Edition, Andrew John De Mello, Joshua Edel, Andrew John De Mello, Springer, 2008.

Research papers/References:

- Physical properties of fluid
- Fabrication Techniques to Realize CMOS-Compatible Microfluidic Microchannels, Angela Rasmussen and Mona E. Zaghloul, Journal Of Microelectromechanical Systems, Vol. 10, No. 2, June 2001, 286.
- Electrowetting: from basics to applications, Frieder Mugele and Jean-Christophe Baret, J. Phys.: Condens. Matter 17 (2005) R705–R774.

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc. Physics (Semester-III)
PS 912 Vacuum Technology

(Elective)

Credit: 2

A. Objective of the course.

- The objective of the course is to give an introductory knowledge of vacuum technology and handling of instruments having high vacuum.
- The students will gain insight into the various measurement parameters of detection of vacuum.
- The course provides a basis for understanding vacuum systems, components, its applications, measurement of leak detection, etc.
- These skills will facilitate the students to gain the sound knowledge of vacuum related technology in the context of applied research or industrial R&D.

B. Outline of the Course

Sr No.	Title of Unit	No. of hrs
1.	PHYSICS OF RAREFIED GASES	7h
2.	PRODUCTION OF VACUUM	4h
3.	MEASUREMENT OF VACUUM PARAMETERS	3h
4.	VACUUM SYSTEMS, COMPONENTS	3h
5.	APPLICATIONS OF VACUUM TECHNOLOGY	3h

A. Syllabus Topics: [1L+1L]

PART A : THEORY

1. PHYSICS OF RAREFIED GASES: Kinetic Theory, Gas Laws, Mean Free path, Transport Processes, Viscosity of gases, Diffusion of gases, Resistance and conductance of vacuum pipework, Gas flow in pipework, Pump-down Time, Adsorption and Desorption of gases, Solubility of gases, Permeation of gases through solids, Vapour pressure, Thermal dissociation of Metallic Oxides
2. PRODUCTION OF VACUUM: Classification, types, and ranges of vacuum pumps, Vacuum pump variables, Baffles and Traps.
3. MEASUREMENT OF VACUUM PARAMETERS: Classification, types and ranges of vacuum gauges, Measurement of Partial pressure, Flow measurement, Leak Testing.
4. VACUUM SYSTEMS, COMPONENTS: Vacuum System engineering, Vacuum joints, Seals, Valves, feed-through, View ports, Vacuum materials.
5. APPLICATIONS OF VACUUM TECHNOLOGY: Vacuum systems and components for Electronics, Metallurgy, Chemical and Nuclear fields.

PART B : PRACTICALS

1. Evacuation of a System Using a Water Ring Pump & Use of Dial Gauge
2. Evacuation of a System Using Rotary Vacuum Pump & Use of Pirani Gauge
3. Evacuation of a System Using a Diffusion Pump & Use Of Penning Gauge
4. Measurement of Helium Leak Rate Using MSLD Technique.

B. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class-room sessions using classical black-board teaching to power-point presentations. Practical sessions may be conducted in the laboratory or in the established R & D laboratory. Respective faculty members on weekly basis will conduct special interactive problem solving sessions during the tutorial session. Students will be trained for the advance level 'hands-on' experiments. Unit tests and assignments will be conducted regularly as a part of continuous evaluation and instruction will be provided to student in order to improve their performance.

C. Student Learning Outcomes / objectives:

- The Program aims at providing students with the methodological concepts and tools needed to acquire top-level skills in the field of vacuum technology.
- Ensuring that students acquire sound knowledge base for future research in applied Physics as well as for students who wish to work in interdisciplinary area.
- During this course, students will do experiments to enhance their conceptual understanding.

D. Recommended Study Material:

Reference Books

1) Fundamentals of Vacuum Techniques, by A Pipko, V. Pliskovsky, B. Korolev, V. Kuznetsov, Mir Publishers, Moscow 1984.
2) Scientific Foundations of Vacuum Technique, by S Dushman, John Wiley & Sons Inc. New York 1962.
3) Vacuum Technology and Applications, by D J Hucknall, Butterworth-Heinemann, Oxford, 1991.

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc. Physics (Semester-III)
PS913 Fluid Dynamics

(Elective)

Credit: 2

A. Objective of the course:

- To introduce basic mathematical properties of fluid.
- To prepare students for application in astrophysics.
- To construct astrophysical models.
- To serve prerequisite for other A&A courses.

B. Outline of the course:

Sr. No	Title of Unit	No. of hours
1	Basic Fluid Equation	15
2	Simple models of Astrophysical fluids and their motion	15

A.Syllabus Topics:

Basic Fluid Equation

1. The Material Derivative
2. The Continuity Equation
3. The Momentum Equation
4. Newtonian Gravity
5. The Mechanical and Thermal Energy Equations
6. Perfect Gases
7. The Virial Theorem
8. Vorticity

Simple models of Astrophysical Fluids and Their Motions

1. Hydrostatic Equilibrium for a Self Gravitating Body
2. Equations of Stellar Structure
3. Small Perturbations about Equilibrium
4. Lagrangian Perturbations
5. Sound Waves
6. Surface Gravity Waves
7. Phase Speed and Group Velocity
8. Order of magnitude estimate for astrophysical fluids---typical scales, viscosity, etc
9. Theory of Rotating Bodies
10. Fluid Dynamical Instabilities

B. Instruction method and pedagogy:

Stress on the conceptual part of the subject and develop the mathematical skill. It will mostly be the black board teaching, but in some case projector will be use. Student will be asked to solve assignments and develop simple computer program to solve simple problems in fluid dynamics.

C. Recommended Study Material:

1. An Introduction to Astrophysical Fluid Dynamics--Michael J Thompson
2. Physics of Fluids and Plasma-- Arnab Rai Choudhuri. Part 1 of this book

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc. Physics (Semester-III)
PS914 Stellar Astrophysics 1
(Elective)

Credit: 2

A. Objective of the course:

- To demonstrate the applications of physics in stars
- To explain the internal dynamics of stars and their formation

B. Course Outline of the course:

Sr. No.	Title of Unit	No. of hours
1	Basic Concept	5
2	Stellar Formation	10
3	Radiative Transfer in Stars	15

A.Syllabus Topics:

Basic Concepts

1. The electromagnetic spectrum
2. Blackbody radiation
3. Lumunisity, Effective temperature, Flux and Magnidude
4. Boltzmann and Saha Equations
5. Spectral Classification of Stars
6. The Hertzsprung Russel diagram

Stellar Formation

1. Hydrostatic Equilibrium
2. The Viral Theorem
3. The Jeans Criteria
4. Free Fall times
5. Pre-Main-Sequence Evolution

Radiative Transfer in Stars

1. Radiative Opacities
2. Specific Intensities and Radiative Moments
3. Radiative Transfer Equations
4. Local Thermodynamic Equilibrium
5. Solution of the Radiative Transfer Equation
6. Radiative Equilibrium
7. Radiative Transfer at Large Optical Depths
8. Rosseland and other Mean Opacities
9. Schwarschild Milne Equations
10. Demonstration of the Radiative Transfer Equations
11. Radiative Acceleration of Matter and Radiative Pressure

B. Instruction method and pedagogy:

Teaching will be done using black-board and often make use of projector for some simulations and astronomical pictures. Emphasis will be given on development of concept and analytical skill. Students will be given sets of assignment and class tests.

C. Recommended Reading Materials:

- Astrophysics for Physicists—Arnab Rai Choudhuri

M. Sc. (Physics) Programme

SYLLABI

(Semester – IV)

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc Physics (Semester-IV)
PS 951 Molecular Physics

Credit: 2

A. Objective of the course.

- The objective of the course is to introduce students to molecular spectroscopy.
- To understand the types of molecular spectra and molecular energy states, its implications in the betterment of life.
- To solve and understand problems related to the molecular spectroscopy.

B. Outline of the Course

Sr No.	*Title of topics*	*No. of hrs*
3.	Vibrational and Rotational spectroscopy	*6h*
4.	Raman spectra and NMR	*8h*
5.	Co-relation between Atomic and Molecular states: Building-up principle	*6h*

A. Syllabus Topics: [1L + 1T]

1. Vibrational and Rotational spectroscopy & NMR: Electronic, Rotational, Vibrational and Raman spectra of diatomic molecules
2. Electronic spectra: Frank-Condon principle, NMR, ESR
3. Co-relation between Atomic and Molecular states: Building-up principle

B. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in the laboratory. Special interactive problem solving sessions will be conducted by respective faculty members on weekly bases during the tutorial session. Students will be trained as per JRF method of examination. Unit tests and assignments will be conducted regularly as a part of continuous evaluation and instruction will be provided to student in order to improve their performance.

C. Student Learning Outcomes / objectives:

- The Program aims at providing students with the methodological concepts and tools needed to acquire understanding in spectroscopy with reference to atomic and molecular spectroscopy.

- At the end students would gain experience in the problem solution which will help him to clear JRF examination.

D. Recommended Study Material:

6. Atomic and Molecular Spectra: Laser – by Raj Kumar (Kedar Nath Ram Nath publications)
7. Physics of Atoms and Molecules – by B. Bransden and C. J. Joachain (Pearson Education Publication (New Delhi)
8. Elements of spectroscopy – by Gupta, Kumar and Sharma (PragatiPrakashan Meerut)
9. Spectroscopy (Atomic and molecular) by G. Chatwal and S. Anand.
10. Spectroscopy, Barrow

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY
DEPARTMENT OF PHYSICAL SCIENCES
M.Sc Physics (Semester-IV)
PS 952 Nuclear Physics and Elementary Particle Physics

Credit: 3

A. Objective of the course

- The objective of the course is to introduce students to Basic nuclear properties.
- To explore the fundamental concepts of experimental nuclear physics.
- To provide problem solving techniques using experimental methods.

B. Outline of the Course

Sr. No.	Title of Unit	No. of hrs
1.	Nuclear Models & Radioactivity	10
2.	Nuclear force & Deuteron problems	10
3.	Particle physics	10

A. **Syllabus Topics:** **[2L + 1T+2P]**

Prerequisite:

Basic Nuclear Properties: Size, Shape and Charge Distribution, spin, Parity, Binding energy, Semi-empirical Mass formula.

1. Nuclear Models & Radioactivity: Evidence of Shell model, single particle shell model and its validity and limitation, Rotational Spectra, Elementary ideas about alpha, beta and gamma decay, Fission and fusion, Nuclear reactions.
2. Nuclear force and Deuteron problem: Nature of nuclear forces, Meson theory of nuclear forces, deuteron problem.
3. Particle Physics: Classification of fundamental forces, Elementary particle physics and their quantum numbers, Quark model, Gell-Mann-Nishijima formula, Relativistic kinematics. Basic Ideas about unification of forces.

B . Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in the laboratory. Special interactive problem solving sessions will be conducted by respective faculty members on weekly bases during the tutorial session. Students will be trained as per JRF method of examination. Unit tests and assignments will be conducted regularly as a part of continuous evaluation and instruction will be provided to student in order to improve their performance.

Visit to scientific labs of national repute to give insight to the subject will be provided. The visit report will be counted in the internal assessment either through submission or seminar/viva.

C. Student Learning Outcomes / objectives:

- The Program aims at providing students with the methodological concepts and tools needed to acquire top-level skills in the field of Nuclear & Particle physics
- Ensuring that students acquire sound knowledge base for future research in nuclear Physics as well as for students who wish to work in reactor physics area.
- During this course, students will do experiments to enhance their conceptual understanding.
- At the end students would gain experience in the problem solution which will help him to clear JRF examination.

D. Recommended Study Material:

1. 'Introduction to Nuclear Physics' by H Enge, Addison-Wesley Pub.
2. 'Introductory Nuclear Physics' by Kenneth S Krane, John Wiley & Sons, Singapore (1988) latest edition
3. 'Fundamentals of Nuclear Physics' by J. C. Verma, R. C. Bhandari & D.R.S. Somayajulu (2005) CBS Publishers & Distributers, New Delhi.
4. 'An Introduction to Engineering Aspects of Nuclear Physics' by Santanu Ghosh (2009), I K Int. Publishing House Pvt.Ltd, New Delhi
5. 'Introduction to Particle Physics' by M P Khanna, Prentice Hall of India (1999) New Delhi
6. 'An Introduction to Nuclear Physics' by W N Cottingam & Greenwood, Cambridge Uni Press UK – latest edition
7. 'Introduction to High energy Physics' by D H Perkins, Addison Wesley

8. 'Introduction to Elementary particles' by David Griffiths, John Wiley & Sons Singapore (1987)
9. 'Introduction To Nuclear And Particle Physics' by Verma R C , Mittal V K and Gupta S C, Prentice Hall of India (2009), New Delhi

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc Physics (Semester-IV)
PS 953 Solid State Physics-II

Credit: 2

A. **Objective of the course.**

- The understand importance of quantum mechanics application to solids.
- To understand formation of band structure in solids.
- To understand semiconductor properties based on band structure.
- Superconductivity and magnetism based on band theory.
- To provide problem solving techniques.

D. **Outline of the Course**

Sr. No.	Title of Unit	No. of hrs
1.	Electron motion in periodic potential & band theory of solids	10
2.	Super conductivity & magnetism	08
3.	Order phase of matter	06
4.	Properties at nanoscale (brief)	06

A. **Syllabus Topics:** [1L + 1T]

Electron motion in a periodic potential, band theory of solids; metals, insulators semiconductors. Superconductivity: type-I and type-II superconductors, Josephson junctions, super fluidity, basics of magnetism, types of magnetism. Ordered phases of matter; translational and orientational order, kinds of liquid crystalline order, Quasi crystals. Alteration of physical, properties of nanoparticles (an introduction)

B . Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Each lecture will follow with three questions, which will be answered in the class teaching. The problem solving sessions will be conducted during the tutorial session. Students will be trained as per JRF method of examination. Unit tests will be conducted regularly as a part of continuous evaluation and instruction will be provided to student in order to improve their performance.

C. Student Learning Outcomes / objectives:

- At the end of the course student should be able to understand importance of quantum mechanical treatment to understand solid state physics.
- Basics origin of superconductivity and how to tune the properties.
- How magnetic, thermal and electrical properties of materials changes at nanoscale.
- At the end students would gain experience in the problem solution which will help him to answer few JRF examination questions related to these topics.

D. Recommended Study Material:

Text books/Reference books

- Crystals and Crystal structures: Richard Tilley, John Wiley & Sons, Ltd, 2006
- C. Kittel, Introduction to Solid State Physics, Wiley India Pvt. Ltd., 2012.
- M. Ali Omar, Elementary Solid State Physics, Pearson, 1st edition, 2008.
- A J Dekker, Solid State Physics, McMillan India Ltd., 1st edition, 2008.
- J. Ziman, Principles in the Theory of Solids, 2nd ed., Cambridge University Press, 1972.
- N. Ashcroft and N. D. Mermin, Solid State Physics, Cengage India Ltd., 1st edition, 2003.

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc Physics (Semester-IV)
PS 954 Project

Credit: 13 (15 hrs/week)

A. Objective of the course.

1. The objective of the course is to expose students to projects based on the research going on in the physical sciences.
2. Instruments training will be given to students.
3. In this course, students will be trained to write project report as well as methodology of working in research.
4. This training will benefit student in their future research work.

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc Physics (Semester-IV)
PS 955 Nuclear Reactor, Nuclear energy & Nuclear accelerators (Elective)

Credit: 2

A. **Objective of the course.**

- The objective of the course is to introduce students to nuclear reactor physics
- To explore the fundamental concepts of moderation in reactor design.
- To provide problem solving techniques using design problems.
- To understand nuclear hazard and its importance
- To introduce students to basics accelerators
- Application of accelerators for scientific studies.

B. Outline of the Course

Sr No.	*Title of topics*	*No. of hrs*
1.	Reactor Physics	*10h*
2.	Nuclear energy and environment	*10h*
3.	Different types of accelerators and their importance	*10h*

A. Syllabus Topics **[1L + 1T]**

Prerequisite: Nuclear reactions: Types of reactions, Cross-sections of reactions, Reaction mechanism.

1. Reactor Physics: Types of reactors, Reactor terminology, Neutron physics, Moderations, Neutron cycle, Diffusion equation, Criticality conditions.
2. Nuclear energy & environment: Fuel production, engineered safety features, Radiation dosage and safety, Fuel processing and waste disposal, Waste management.
3. Basics Accelerator physics: Electrostatic accelerators, Cyclotron, Synchrotrons, Linear accelerators, Colliding-beam accelerators

B. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. The course will be based on the discussion and hence motivate students to participate.

C. Student Learning Outcomes / objectives:

By the end of the course you should be able to

- Understand basic reactor physics and nuclear safety aspects.
- Practical use of nuclear reactors and accelerators

D. Recommended Study Material:

1. 'Introduction to Nuclear Physics' by H Enge, Addison-Wesley Pub.
2. 'Introductory Nuclear Physics' by Kenneth S Krane, John Wiley & Sons, Singapore (1988) latest edition
3. 'Fundamentals of Nuclear Physics' by J. C. Verma, R. C. Bhandari & D.R.S. Somayajulu (2005) CBS Publishers & Distributers, New Delhi.
4. 'An Introduction to Engineering Aspects of Nuclear Physics' by Santanu Ghosh (2009), I K Int. Publishing House Pvt.Ltd, New Delhi
5. 'An Introduction to Nuclear Physics' by W N Cottingam & Greenwood, Cambridge Uni Press UK – latest edition
6. Introduction to Nuclear Science & technology, K S Ram & Y R Waghmare.
7. Nuclear Reactor Physics: Stacey W. M.
8. Particle Accelerators: Livingston & Blewett

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc Physics (Semester-IV)
PS 956 Electromagnetic Radiation
(Elective)

Credit: 2

E. **Objective of the course.**

The objective of the course is to introduce electromagnetic radiation, potentials and fields

F. **Outline of the Course**

Sr. No.	Title of Unit	No. of hrs
1.	Potentials and fields	10h
2.	Radiations	10h

A. **Syllabus Topics:** [1L + 1T]

1. Potentials and fields: The potential formulation, continuous distribution, retarded potentials, Lienard-Wiechert potentials, the field of moving point charges, and Antenna (Chap. 10, Griffith)
2. Radiation: Dipole radiation, Radiation by point charges. (Chap. 11, Griffith)

B . Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in the laboratory. Special interactive problem solving sessions will be conducted by respective faculty members on weekly bases during the tutorial session. Students will be trained as per JRF method of examination. Unit tests and assignments will be conducted regularly as a part of continuous evaluation and instruction will be provided to student in order to improve their performance.

C. Student Learning Outcomes / objectives:

- At the end of the program students will understand electromagnetic radiation and potential which are useful in electrodynamics.

D. Recommended Study Material:

Text books/Reference books

6. Introduction to Electrodynamics, David J. Griffiths, PHI publication, 3rd edition, 1999.
7. Classical Electrodynamics, John David Jackson, John Wiley & Sons, Inc., 3rd edition, 1998.
8. Elements of Engineering Electromagnetics, Narayana Rao, N., Prentice-Hall of India 5th Ed., 2002
9. Engineering Electromagnetics: Hayat & Buck, Mc-Graw Hill.
10. Elements of Electromagnetics, Matthew N. O. Sadiku

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES

M.Sc Physics (Semester-IV)

PS 957 Nanofluids

(Elective)

Credit: 2

A. *Objective of the course.*

- The objective of the course is to give an introductory knowledge of nanofluids.
- The students will gain insight into the various techniques of synthesis of nanoparticles and nanofluids.
- The course provides a basis for estimating physical quantities such as thermal conductivity, specific heat capacity, viscosity of nanofluids, etc.
- These skills will facilitate the students to gain the sound knowledge of synthesis and characterization of nanoparticles and nanofluids in the context of applied research or industrial R&D.

B. Outline of the Course

Sr No.	Title of Unit	No. of hrs
1.	Introduction of Nanofluids	3h
2.	Synthesis of Nanoparticles & Nanofluids	6h
3.	Measurements in Nanofluids, Models and Mechanisms	6h
4.	Applications of Nanofluids	5h

A. Syllabus Topics: [1L-1T]

Introduction: Background of Nanofluids, Synthesis of Nanoparticles – Synthesis & Characterization, Making of Nanofluids: Dispersion of Nanoparticles in Liquids-Physical Methods, Chemical Methods, Direct Evaporation-Condensation Methods.

Measurements in Nanofluids: Methods of Measuring-Thermal conductivity, Thermal conductivity of types of nanofluids: Oxide Ceramic Nanofluids, Nonoxide Ceramic Nanofluids, Metallic Nanofluids, MWNT Nanofluids, Viscosity, Convection Heat Transfer.

Models and Mechanisms: Effective Thermal Conductivity Models, Potential Mechanisms for Enhanced Conductivity, Thermal Transport in Nanocomposite Systems.Future Directions

B. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class-room sessions using classical black-board teaching to power-point presentations. Practical sessions may be conducted in the laboratory. Respective faculty members on weekly basis will conduct special interactive problem solving sessions during the tutorial session. Students will be trained for the advance level 'hands-on' experiments. Unit tests and assignments will be conducted regularly as a part of continuous evaluation and instruction will be provided to student in order to improve their performance.

C. Student Learning Outcomes / objectives:

- The Program aims at providing students with the methodological concepts and tools needed to acquire top-level skills in the field of fluid dynamics.
- Ensuring that students acquire sound knowledge base for future research in soft condensed matter Physics as well as for students who wish to work in interdisciplinary area.
- During this course, students will do experiments to enhance their conceptual understanding.

D. Recommended Study Material:

Reference Materials/ Research papers

i. *Encyclopedia of Nanoscience & Nanotechnology Vol. 6 by H S Nalwa, American Scientific Publication. Pg. 739-774.*
ii. *Nanofluids: Science and Technology, Wenhua Yu, T. Pradeep, Sarit K. Das, Stephen U. Choi, John Wiley & Sons Inc, 2007.*
iii. *Experimental Investigation of Thermal Conductivity of Nanofluids, Raghu Gowda, Proquest, Umi Dissertation Publishing, 2011.*
iv. *Study of the Cooling Effects of Nanofluids on Electronic Components and a Sensitivity Analysis of the Most Influential Variable on the Heat Transfer, Stephanie E. Lingo, Proquest, Umi Dissertation Publishing, 2011.*

References:

- Techniques for measuring the thermal conductivity of nanofluids: A review by G. Paul, M. Chopkar, I. Manna, P.K. Das, Renewable and Sustainable Energy Reviews xxx (2010) xxx–xxx.
- Thermal Conductivity Measurement by William A. Wakeham and Marc J. Assael, Copyright 2000 CRC Press LLC. ‹http://www.engnetbase.com›.
- Rendering the Transient Hot Wire Experimental Method for Thermal Conductivity Estimation to Two-Phase Systems—Theoretical Leading Order Results, Peter Vadasz, Journal of Heat Transfer, AUGUST 2010, Vol. 132 / 081601-1.

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc Physics (Semester-IV)
PS 958 Semiconductor Devices
(Elective)

Credit: 2

A.Objective of the course.

- The objective of the course is an advanced understanding of semiconductor physics and the physics and operation of advanced semiconductor devices.
- To give information regarding basic device building blocks from which all semiconductor devices can be constructed.
- The course provides advanced knowledge of device performance and physical principles of operation including DC, AC, and high frequency behavior, sources of noise, and advance modes of operation.
- To give the linking of performance parameters (figures of merit) with underlying semiconductor properties and physical principles of devices.
- To provide foundation in the semiconductor device physics so that students will be able to not only understand current devices and exploit them in novel applications, but also appreciate the workings of new semiconductor devices as they materialize and evolve in future years for applied research or industrial R&D.

B. Outline of the Course

Sr No.	Title of Unit	No. of hrs
1.	Metal-Semiconductor Contacts	5h
2.	Metal-Insulator-Semiconductor Capacitors	5h
3.	Heterojunctions, Heterojunction Bipolar Transistor	3h
4.	MOSFETs, JFETs, MESFETs, and MODFETs	8h

A. Syllabus Topics: [1L-1T]

METAL-SEMICONDUCTOR CONTACTS:
Introduction, formation of barrier, Ideal Condition, Depletion Layer, Interface States, Image-Force Lowering, Barrier-Height Adjustment, Current transport processes, Measurement of barrier height, device structures, Ohmic contact.
METAL-INSULATOR-SEMICONDUCTOR CAPACITORS:
Introduction, Ideal Mis Capacitor, Surface Space-Charge Region, Ideal MIS Capacitance Curves, Silicon Mos Capacitor, Interface Traps, Carrier Transport, Accumulation- and Inversion-Layer Thickness
HETEROJUNCTIONS, HETEROJUNCTION BIPOLAR TRANSISTOR:
Anisotype Heterojunction, Isotype Heterojunction, Heterojunction bipolar transistor, Double-Heterojunction Bipolar Transistor, Graded-Base Bipolar Transistor, Hot-Electron Transistor
MOSFETs, MESFETs, and MODFETs:
Introduction, Basic Device Characteristics, Nonuniform Doping and Buried-Channel Device, Device Scaling And Short-Channel Effects, MOSFET Structures, Circuit Applications, Nonvolatile Memory Devices, Single-Electron Transistor, MESFET, MODFET,I-V Characteristics, Device Structures

B . Instructional Methods and Pedagogy:

The topics will be discussed in interactive class-room sessions using classical black-board teaching to power-point presentations. Practical sessions may be conducted in the laboratory. Respective faculty members on weekly basis will conduct special interactive problem solving sessions during the tutorial session. Wherever possible the emphasis will be on 'hands-on' experiments for the conceptual understanding of device operation. Unit tests and assignments will be conducted regularly as a part of continuous evaluation and instruction will be provided to student in order to improve their performance.

C. Student Learning Outcomes / objectives:

- The student should after the course be able to describe the basic principles of the semiconductor devices; Schottky diode, MOSFET, MESFET and MODFET.
- Other objectives are that the student should know how to manipulate the device parameters and analyze and judge the validity of device models from a device physics point of view for its use in the applied research or industrial R&D
- During this course, students will do experiments to enhance their conceptual understanding.

D. Recommended Study Material:

Text books/Reference books

1. Semiconductor devices- Physics and Technology by S.M. Sze.
2. Semiconductor devices- Basic Principles- Jasprit Singh
3. Metal/Semiconductor Contact: Rhoderick
4. Metal/Semiconductor Schottky Barrier Junction and their Applications: B.L. Sharma
5. Physics of Semiconductor Devices: M. Schur

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES

M.Sc Physics (Semester-IV)

PS 959 Plasma Physics

(Elective)

Credit: 2

A. Objective of the course.

- The objective of the course is to give an introductory knowledge of Plasma physics and technology.
- The students will gain insight into the various techniques of production and the confinement of plasma in laboratory.
- The course provides a basis for plasma diagnostics techniques.
- These skills will facilitate the students to gain the sound knowledge of Plasma physics and technology in the context of applied research or industrial R&D.

B. Outline of the Course

Sr No.	Title of Unit	No. of hrs
1.	PLASMA PHYSICS FUNDAMENTALS	8h
2.	LABORATORY PLASMA PRODUCTION	3h
3.	PLASMA DIAGNOSTIC TECHNIQUES	4h
4.	INTRODUCTION TO FUSION ENERGY	5h

A. Syllabus Topics: [1L+1T]

PART A : THEORY

1. PLASMA PHYSICS FUNDAMENTALS: Definition of Plasma, Concept of Temperature, Debye Shielding, Single particle motions, Plasmas as fluids, Fluid drift in magnetic field, Waves in Plasmas, Group Velocity, Elementary Plasma Waves, Single Fluid MHD equation, Diffusion in fully ionized plasma, Bohm diffusion, Hydromagnetic equilibrium, Two-stream instabillity, "Gravitational" instability, Equations of Kinetic Theory, Landau Damping, Ion-Acoustic Shock wave, Parametric instabilities.
2. LABORATORY PLASMA PRODUCTION: Assembled Plasmas, Irradiated Gases, Electrical Discharges, Self-ionized gases, Optical Radiation.
3. PLASMA DIAGNOSTIC TECHNIQUES: Electric and Magnetic Probes, Spectral Intensities, UV, Far-Infrared and X-ray spectroscopy, Optical interferometry, Microwave Techniques.
4. INTRODUCTION TO FUSION ENERGY: Basic Principles, Plasma confinement and Transport, Plasma Heating and Fueling, Advanced confinement concepts, Fusion engineering, Fusion Reactor Technology.

PART B : PRACTICALS

1. Production of a Glow Discharge
2. Production of a Hot Cathode Discharge and Measurement Of Plasma Density And Temperature Using Langmuir Probes.
3. Extraction of Ions from Plasma
4. Cusp Confinement Plasma System

B. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class-room sessions using classical black-board teaching to power-point presentations. Practical sessions may be conducted in the laboratory. Respective faculty members on weekly basis will conduct special interactive problem solving sessions during the tutorial session. Unit tests and assignments will be conducted regularly as a part of continuous evaluation and instruction will be provided to student in order to improve their performance.

C. Student Learning Outcomes / objectives:

- The Program aims at providing students with the methodological concepts and tools needed to acquire top-level skills in the field of Plasma Physics and technolgy.
- Ensuring that students acquire sound knowledge base for future research in Plasma Physics as well as for students who wish to work in interdisciplinary area.
- During this course, students will do experiments to enhance their conceptual understanding.

D. Recommended Study Material: Reference Books

1) Introduction to Plasma Physics, by Francis F Chen, Plenum Press New York 1977.
2) Plasma Diagnostic Technique, by R H Huddlestone and S L Leonard, Academic Press 1965.
3) Plasma Physics in Theory and Application, by W B Kunkel, McGrawHill, New York 1966.
4) Introduction to Fusion Energy, by J Reece roth, Ibis Publishing, Virginia, 1986.

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc Physics (Semester-IV)
PS 960 Advanced Magnetism
(Elective)

Credit: 2

A. Objective of the course.

- The objective of the course is to introduce students to various magnetic properties of solids.
- To explore the basics fundamental concepts of magnetism in experimental condensed matter physics.
- To provide analytical solution of various techniques using experimental methods.

B. Outline of the Course

Sr No.	Title of Unit	No. of hrs
1.	Review of origin of magnetism	2h
2.	Ordered magnetic materials	6h
3.	Exchange interactions, soft and hard magnetic materials	5h
4.	spin glass & magnetic frustration	3h
5.	Experimental techniques	4h

A. Syllabus Topics: [1L+1T]

Atomic origin of magnetism, diamagnetism, paramagnetism, magnetizations and magnetically ordered materials: ferromagnetism, antiferromagnetism and ferrimagnetism, various types of exchange interactions: magnetic anisotropy and aniotropy energies, crystal field effects, soft and hard magnetic materials: spinel, garnet, hexaferrite and perovskite, magnetic hysteresis and superparamagnetism, spin glass, magnetic frustration, low dimensional and molecular magnetism. Specific characterization techniques for magnetic materials like single crystal, polycrystalline, nano size and amorphous magnetic materials such as SQUID, VSM, Ac susceptometer, FMR, Neutron diffraction, MFM & MOKE (brief)

B. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class-room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in the laboratory. Special interactive problem solving sessions will be conducted by respective faculty members on weekly bases during the tutorial session. Students will be trained for the advance level understanding of fundamental concepts of magnetism. Unit tests and assignments will be conducted regularly as a part of continuous evaluation and instruction will be provided to student in order to improve their performance.

C. Student Learning Outcomes / objectives:

- The Program aims at providing students with the methodological concepts and tools needed to acquire top-level skills in the field of condensed matter physics.
- Ensuring that students acquire sound knowledge base for future research in condensed matter Physics as well as for students who wish to work in interdisciplinary area.
- During this course, students will do experiments to enhance their conceptual understanding.

D. Recommended Study Material:

Text books/Reference books

1. Introduction To Magnetic Materials, B. D. Cullity & C. D. Graham, 2nd Edition, John Wiley & Sons, Inc., Hoboken, New Jersey, 2009.
2. Magnetism and Magnetic Materials, J. M. D. Coey, Cambridge University Press, 2009.
3. Magnetic Materials-Fundamentals and Applications, Second edition, Nicola A. Spaldin, Cambridge University Press, 2010.
4. C. Kittel, Introduction to Solid State Physics, Wiley India Pvt. Ltd., 2012.
5. Michael Ziese , Martin J Thornton (Eds), Spin Electronics, Springer, 2001.
6. H. S. Nalwa (Ed), Magnetic Nanostructures, American Scientific Publishers, 2002.
7. J.A.C.Bland and B.Heinrich (Eds), Ultrathin Magnetic Structures, Springer, 1994.
8. G. J. Long and F. Grandjean (Eds), Supermagnets, Hard Magnetic Materials, Kluwer Academic Publishers, 1991.

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc Physics (Semester-IV)
PS 961 Advanced Microprocessor
(Elective)

Credit: 2

A. **Objective of the course.**

To have an in depth knowledge of the architecture of 8-bit microprocessor -8085, to study the Instruction set and to develop assembly language programs.

B. outline of the Course

Sr No.	*Title of Unit*	*No. of hrs*
1.	Introduction to 8085, Microprocessor architecture and its operations	*2h*
2.	Memory and I/O devices, Microprocessor based systems	*2h*
3.	Interfacing I/O devices, Memory mapped I/O, Programming the 8085 – addressing modes introduction to 8085 instructions , (data transfer, arithmetic)	*5h*
4.	8085 instructions(logical, branch operations), Programming techniques – Looping, Counting and Indexing	*3h*
5.	Stack and sub routine, Code conversion	*2h*

A. Syllabus Topics: [1L + 1T]

1. Introduction to 8085
2. Microprocessor architecture and its operations
3. Memory and I/O devices
4. Microprocessor based systems
5. Interfacing I/O devices
6. Memory mapped I/O
7. Programming the 8085 – addressing modes introduction to 8085 instructions (data transfer, arithmetic)8085 instructions(logical, branch operations)
8. Programming techniques – Looping, Counting and Indexing
9. Stack and sub routine
10. Code conversion

B. Recommended Study Material:

Text Books:

1. Ramesh S.Gaonkar, "Microprocessor - Architecture, Programming and Applications with the 8085", Penram International publishing private limited, fifth edition.

Reference Books:

1. N. K. SRINATH, 8085 Microprocessor: Programming And Interfacing, PHI Learning Pvt. Ltd.
2. Sunil Mathur, Microprocessor 8085 and Its Interfacing, PHI Learning Pvt. Ltd. (2010)
3. K. Udaya Kumar, The 8085 Microprocessor: Architecture, Programming and Interfacing, Pearson Education India, 2008

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES

M.Sc. Physics (Semester-IV)

PS962 Astrophysical Plasma

(Elective)

Credit: 2

A. Objective of the course

- To develop the idea of physics of plasmas
- To explain various processes in plasmas applicable to astrophysics

B. Course Outline of the course

Sl. No	Title of the Unit	No. of hours
1	Plasma Orbit Theory	15
2	Dynamics of Many Charged Particles	10
3	Collisionless processes in Plasma	5

[1L + 1T]

A. Syllabus Topics:

Plasma orbit theory

1. Effect of perpendicular force, gradient drift, curvature drift
2. Magnetic mirror
3. Formation of the Van Allen belt
4. Cosmic rays, particle acceleration in astrophysics

Dynamics of many charged particles

1. Basic properties of plasmas
2. Debye shielding, the plasma parameter
3. Different types of plasmas
4. BBGKY hierarchy
5. Vlasov Equation
6. Fokker-Planck equation

Collisionless processes in plasma

1. Electromagnetic oscillation in cold plasmas, plasma oscillation, electromagnetic waves
2. Warm plasma waves
3. Vlasov theory of plasma waves
4. Electromagnetic wave propagation parallel to magnetic field, Farady rotation.

B. **Instruction method and pedagogy**

Teaching will be done using blackboard with emphasis on the development of concept. Student will be asked to solve assignments. The main stress will be given to understanding of plasma physics in relation to astrophysical processes.

C. Recommended Study Materials:

1. Physics of Fluids and Plasma-- Arnab Rai Choudhuri
2. Physics of Plasmas--Boyd and Sanderson

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCES
M.Sc. Physics (Semester-IV)
PS963 Stellar Astrophysics 2
(Elective)

Credit 2

A. Objective of the course

- ➢ Explain the various processes in stars
- ➢ Details explanation about the life of stars
- ➢ To develop the skill for higher studies in astrophysics

B. Course Outline of the course

Sl No	Title of Unit	No. of Hours
1	Stellar Atmosphere	6
2	Stellar Interior	6
3	Nucleosynthesis and Stellar Evolution	12
4	Stellar End States	6

A.Syllabus Topics

Stellar Atmosphere

1. The Grey Atmosphere
2. Line Opacities and Broadening
3. Equivalent Width and Formation of Atomic Lines
4. Atmospheric Modelling

Stellar Interior

1. Equation of Stellar Structure
2. Energy Transport in Stars
3. Polytropic Models
4. Structure of the Equation of State
5. Variable Stars and Astroseismology

Nucleosynthesis and Stellar Evolution

1. Heavy Element Generalities Concerning Nuclear Fusion
2. Models of the Nucleus
3. Basic Physics of Nuclear Fusion
4. Main Sequence Burning
5. Helium Burning Phase
6. Advanced Nuclear Burning
7. Evolutionary Tracks in the H-R diagram
8. Stellar Clusters
9. Stellar Remnants
10. Novae and Supernovae
11. Nucleosynthesis
12. Nuclear Reaction Cross Sections and Rates

Stellar End States

1. Degeneracy Pressure of Fermi Gas
2. Structure of White Dwarf: Chandrasekhar Mass Limit
3. Neutron Drip and Neutron Star
4. Pulsar

B. Instruction method and pedagogy

Teaching will be done using black-board and often make use of projector for some simulations and astronomical pictures. Emphasis will be given on development of concept and analytical skill. Students will be given sets of assignment and class tests. Develop analytical skill to handle open problems in astrophysics.

C. Recommended Study Materials

- Astrophysics for Physicists—Arnab Rai Choudhuri

Amendment in the pedagogy: Scientific and academic visit to Institute of national repute

An amendment in the pedagogy has been added as: "Visit to scientific labs of national repute to give insight to the subject will be provided. The visit report will be counted in the internal assessment either through submission or seminar/viva." In the following courses:

Course code	Page No.
PS 903 Analytical Techniques	49
PS 907 Thin Film Technology	55
PS 952 Nuclear Physics and Elementary Particle Physics	71