BANASTHALI VIDYAPITH

Master of Science (Physics)

Curriculum Structure

First Semester Examination, December, 2020
Second Semester Examination, April/May, 2021
Third Semester Examination, December, 2021
Fourth Semester Examination, April/May, 2022

BANASTHALI VIDYAPITH
P.O. BANASTHALI VIDYAPITH
(Rajasthan)-304022

July, 2020

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No. F. 9-6/81-U.3

Government of India
Ministry of Education and Culture
(Department of Education)

New Delhi, the 25th October, 1983

NOTIFICATION

In exercise of the powers conferred by Section 3 of the University Grants Commission Act, 1956 (3 of 1956) the Central Government, on the advice of the Commission, hereby declare that Banasthali Vidyapith, P. O. Banasthali Vidyapith, (Rajasthan) shall be deemed to be a University for the purpose of the aforesaid Act.

Sd/-
(M. R. Kolhatkar)
Joint Secretary of the Government of India

NOTICE

Changes in Bye-laws/Syllabi and Books may from time to time be made by amendment or remaking, and a Candidate shall, except in so far as the Vidyapith determines otherwise, comply with any change that applies to years she has not completed at the time of change.

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Programme Educational Objectives

Among various science subjects, Physics is a natural science which deals with the behavior of matter, energy and the natural laws. The core theories of Physics are: Classical Mechanics, Electromagnetism, Thermodynamics and Statistical Mechanics, Quantum Mechanics and Relativity. There are many more branches of Physics like including astronomy, biophysics, atmospheric physics, nuclear physics etc. Therefore, Physics plays a key role in the future progress of humankind either in education or research in the world because of its characteristics features.

Keeping in views the entire scientific development of the student through covering almost all the courses, the M.Sc. (Physics) programme has been designed. The present programme aims to train the students to acquire high level theoretical and experimental knowledge in Physics through learning the designed studies with high quality and significance. However, the main objectives of the programmes are as follows:

- To provide the fundamental concepts of nature in terms of physics with their utilizations
- To produce M.Sc. students who are very knowledgeable and theoretically sound and are able to apply these for the analysis and solution of problems where these leads to new or substantially improved insights and performances.
- To provide the knowledge of various new techniques by which the students can lead the cutting edge technologies
- To encourage research and development activities
- To prepare the competent physicists at national and international level
- To produce M.Sc. students with high integrity having social values and who are ethically professional
- To produce M.Sc. students who can think critically and creatively thus capable of generating and developing new knowledge, products, materials or methods for the benefits of mankind.
- To produce M.Sc. students with excellent communication skills, capable of communicating effectively in various context, thus sharing new knowledge with other researchers from other institutions, universities and also industrialists
- To develop gender –neutral attitudes and practices; respect for all races, nations, religions, culture, languages and traditions
- To produce M.Sc. students who can adapt to changes in environment and practice lifelong learning
- To provide the ideas about pollution control and environment sustainability through exemplary education

Programme Outcomes

PO1 : **Physics Knowledge:** Possess fundamental knowledge of various core courses of physics to solve complex scientific problems of the society. Also, the students will be able to apply theoretical knowledge of principles and concepts of Physics to practical problems

PO2 : **Planning Abilities-**Ability to demonstrate efficient planning including time management, resource management and organization skills.

PO3 : **Expert of Advanced Tool:** Expertise in new and advanced techniques like photo-sepectrometer, XRD, FESEM, Raman, DSC etc. through project component of the programme.

PO4 : **Problem analysis ability-**Ability to apply physics principles alongwith other scientific conceptual attitude to analyze the problems related to society and to show the caliber for finding the solution.

PO5 : **Leadership Skills-** ability to have leadership skills with high regard for ethical values and social responsibilities through learning of time management and team work skill.

PO6 : **Professional Identity-** Possess ability to prove professional identity in any institution and industry at national and international level

PO7: Physics and society-Ability to explain the understanding of impact of physics study on the society including pollution, environment, health and ecosystem. In addition, the students will be able to propagate their knowledge to address problems of social relevance such as energy, and environment through their specific electives.

PO8 : Communication-Possess effective communication skills, teamwork skills, multidisciplinary approach, and an ability to relate the role of physics to address environmental issues.

PO9 : environment and sustainability- Understanding about environment sustainability and pollution control through project and laboratory practices

PO10 : Life-long learning- Possess the knowledge of current issues and ability to engage in life-long learning

Curriculum Structure
Master of Science (Physics)

First Year

Semester - I

Course Code		Course Name	L	T	P	C*
PHY	403	Classical Mechanics	4	0	0	4
PHY	404	Mathematical Physics	4	0	0	4
PHY	406	Quantum Mechanics - I	4	0	0	4
ELE	406	Principles of Digital Electronics	4	0	0	4
ELE	406L	Principles of Digital Electronics Lab	0	0	4	2
CS	416	Computer Programming	4	0	0	4
CS	416L	Computer Programming Lab	0	0	8	4
		Semester Total:	**20**	**0**	**12**	**26**

Semester - II

Course Code		Course Name	L	T	P	C*
PHY	401	Atomic and Molecular Physics	4	0	0	4
PHY	402	Classical Electrodynamics - I	4	0	0	4
PHY	405L	Physics Lab - I	0	0	8	4
PHY	407	Quantum Mechanics - II	4	0	0	4
PHY	408	Statistical Mechanics	4	0	0	4
TSKL	404	Communication Skills	2	0	0	2
CS	414	Computer Oriented Numerical and Statistical Methods	4	0	0	4
CS	414L	Computer Oriented Numerical and Statistical Methods Lab	0	0	4	2
		Semester Total:	**22**	**0**	**12**	**28**

Second Year

Semester - III

Course Code		Course Name	L	T	P	C*
PHY	504	Classical Electrodynamics - II	4	0	0	4
PHY	516	Nuclear Physics - I	4	0	0	4
PHY	538	Physics of Lasers and Laser Applications	4	0	0	4
PHY	530	Solid State Physics	4	0	0	4
PHY	537L	Physics Lab - II	0	0	8	4
PHY	527S	Seminar	0	0	2	1
		Discipline Elective	4	0	0	4
		Reading Elective	0	0	4	2
		Semester Total:	**20**	**0**	**14**	**27**

Semester - IV

Course Code		Course Name	L	T	P	C*
ELE	307	Microwave Electronics	4	0	0	4
PHY	517	Nuclear Physics - II	4	0	0	4
PHY	529	Solid State Electronics Devices	4	0	0	4
PHY	519L	Physics Lab - III	0	0	8	4
PHY	525P	Project	0	0	8	4
		Open Elective	4	0	0	4
		Semester Total:	**16**	**0**	**16**	**24**

List of Discipline Elective

Course Code		Course Name	L	T	P	C*
PHY	534	Condensed Matter Physics - I	4	0	0	4
PHY	507	Fiber Optics Communication	4	0	0	4
PHY	509	High Energy Physics - I	4	0	0	4
PHY	514	Nonlinear Physics - I	4	0	0	4
PHY	521	Physics of Nano - structures and Nanotechnology - I	4	0	0	4
PHY	523	Plasma Physics - I	4	0	0	4
PHY	526	Science and Technology of Solar Hydrogen and other Renewable Energies	4	0	0	4
PHY	532	Biophysics-I	4	0	0	4
PHY	503	Analog and Digital Communication	4	0	0	4
PHY	535	Condensed Matter Physics - II	4	0	0	4
PHY	510	High Energy Physics - II	4	0	0	4
PHY	515	Nonlinear Physics - II	4	0	0	4
PHY	522	Physics of Nano - structures and Nanotechnology - II	4	0	0	4
PHY	524	Plasma Physics - II	4	0	0	4
PHY	528	Solar Energy : Principles of Solar Thermal Devices	4	0	0	4
PHY	533	Biophysics-II	4	0	0	4

List of Reading Elective

Course Code		Course Name	L	T	P	C*
PHY	536R	Optical Materials and Devices	0	0	4	2
PHY	539R	Solar Energy : Photovoltaic Systems	0	0	4	2
ELE	414R	Introduction to Photonics	0	0	4	2

*** L - Lecture hrs/week; T - Tutorial hrs/week; P-Project/Practical/Lab/All other non-classroom academic activities, etc. hrs/week; C - Credit Points of the Course**

Student can opt open (Generic) elective from any discipline of the Vidyapith with prior permission of respective heads and time table permitting.

Every Student shall also opt for:
Five Fold Education: Physical Education I, Physical Education II, Five Fold Education: Aesthetic Education I, Aesthetic Education II, Five Fold Education: Practical Education I, Practical Education II one each semester

Five Fold Activities

Aesthetic Education I/II		Physical Education I/II	
BVFF 101	Classical Dance (Bharatnatyam)	BVFF 201	Aerobics
BVFF 102	Classical Dance (Kathak)	BVFF 202	Archery
BVFF 103	Classical Dance (Manipuri)	BVFF 203	Athletics
BVFF 104	Creative Art	BVFF 204	Badminton
BVFF 105	Folk Dance	BVFF 205	Basketball
BVFF 106	Music-Instrumental (Guitar)	BVFF 206	Cricket
BVFF 107	Music-Instrumental (Orchestra)	BVFF 207	Equestrian
BVFF 108	Music-Instrumental (Sarod)	BVFF 208	Flying - Flight Radio Telephone Operator's Licence (Restricted)
BVFF 109	Music-Instrumental (Sitar)	BVFF 209	Flying - Student Pilot's Licence
BVFF 110	Music-Instrumental (Tabla)	BVFF 229	Aeromodelling
BVFF 111	Music-Instrumental (Violin)	BVFF 210	Football
BVFF 112	Music-Vocal	BVFF 211	Gymnastics
BVFF 113	Theatre	BVFF 212	Handball
Practical Education I/II		BVFF 213	Hockey
BVFF 301	Banasthali Sewa Dal	BVFF 214	Judo
BVFF 302	Extension Programs for Women Empowerment	BVFF 215	Kabaddi
BVFF 303	FM Radio	BVFF 216	Karate - Do
BVFF 304	Informal Education	BVFF 217	Kho-Kho
BVFF 305	National Service Scheme	BVFF 218	Net Ball
BVFF 306	National Cadet Corps	BVFF 219	Rope Mallakhamb
		BVFF 220	Shooting
		BVFF 221	Soft Ball
		BVFF 222	Swimming
		BVFF 223	Table Tennis
		BVFF 224	Tennis
		BVFF 225	Throwball
		BVFF 226	Volleyball
		BVFF 227	Weight Training
		BVFF 228	Yoga

Every Student shall also opt for:
Five Fold Education: Physical Education I, Physical Education II,
Five Fold Education: Aesthetic Education I, Aesthetic Education II,
Five Fold Education: Practical Education I, Practical Education II
one each semester

Evaluation Scheme and Grading System

Continuous Assessment (CA) (Max. Marks)					End-Semester Assessment (ESA) (Max. Marks)	Grand Total (Max. Marks)
Assignment		Periodical Test		Total (CA)		
I	II	I	II			
10	10	10	10	40	60	100

In all theory, laboratory and other non classroom activities (project, dissertation, seminar, etc.), the Continuous and End-semester assessment will be of 40 and 60 marks respectively. However, for Reading Elective, only End semester exam of 100 marks will be held. Wherever desired, the detailed breakup of continuous assessment marks (40), for project, practical, dissertation, seminar, etc shall be announced by respective departments in respective student handouts.

Based on the cumulative performance in the continuous and end-semester assessments, the grade obtained by the student in each course shall be awarded. The classification of grades is as under:

Letter Grade	Grade Point	Narration
O	10	Outstanding
A+	9	Excellent
A	8	Very Good
B+	7	Good
B	6	Above Average
C+	5	Average
C	4	Below Average
D	3	Marginal
E	2	Exposed
NC	0	Not Cleared

Based on the obtained grades, the Semester Grade Point Average shall be computed as under:

$$SGPA = \frac{CC_1 * GP_1 + CC_2 * GP_2 + CC_3 * GP_3 + ---- + CC_n * GP_n}{CC_1 + CC_2 + CC_3 + ---- + CC_n} = \frac{\sum_{i=1}^{n} CC_i * GP_i}{\sum_{i=1}^{n} CC_i}$$

Where n is the number of courses (with letter grading) registered in the semester, CC_i are the course credits attached to the i^{th} course with letter grading and GP_i is the letter grade point obtained in the i^{th} course. The courses which are given Non-Letter Grades are not considered in the calculation of SGPA.

The Cumulative Grade Point Average (CGPA) at the end of each semester shall be computed as under:

$$CGPA = \frac{CC_1 * GP_1 + CC_2 * GP_2 + CC_3 * GP_3 + \text{-----} + CC_n * GP_n}{CC_1 + CC_2 + CC_3 + \text{-----} + CC_n} = \frac{\sum_{i=1}^{n} CC_i * GP_i}{\sum_{i=1}^{n} CC_i}$$

Where n is the number of all the courses (with letter grading) that a student has taken up to the previous semester.

Student shall be required to maintain a minimum of 4.00 CGPA at the end of each semester. If a student's CGPA remains below 4.00 in two consecutive semesters, then the student will be placed under probation and the case will be referred to Academic Performance Review Committee (APRC) which will decide the course load of the student for successive semester till the student comes out of the probationary clause.

To clear a course of a degree program, a student should obtain letter grade C and above. However, D/E grade in two/one of the courses throughout the UG/PG degree program respectively shall be deemed to have cleared the respective course(s). The excess of two/one D/E course(s) in UG/PG degree program shall become the backlog course(s) and the student will be required to repeat and clear them in successive semester(s) by obtaining grade C or above.

After successfully clearing all the courses of the degree program, the student shall be awarded division as per following table.

Division	CGPA
Distinction	7.50 and above
First Division	6.00 to 7.49
Second Division	5.00 to 5.99
Pass	4.00 to 4.99

CGPA to % Conversion Formula: % of Marks Obtained = CGPA * 10

First Semester

PHY 403 Classical Mechanics

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

After successfully completed course, Student will be able to :

- Have a deep understanding of Newtonian mechanics and able to solve the Newton equations for simple configurations using various methods.
- Define and understand basic mechanical concepts related to discrete and continuous mechanical systems.
- Describe and understand the vibrations of discrete and continuous mechanical systems.
- Describe and understand planar and spatial motion of a rigid body.
- Describe and understand the motion of a mechanical system using Lagrange-Hamilton formalism.

Section A

System of particles: Conservation laws, Constrained motion, Constraints, Degree of freedom, Generalised co-ordinates.

generalized force, Principle of virtual work, D'Alembert's principle, Applications of D'Alembert's principle, Deduction of Lagrange's equations of motion by different methods, Lagranges's equation for conservative and non-conservative forces, Symmetry properties for space and time and conservation laws, Hamilton's variational principle, Euler-Lagrange differential equation, Applications of Lagrange's equations of motion: Lagrangian for a charged particle in an electromagnetic field, Small oscillation and Normal modes

Section B

Hamiltonian Dynamics: Hamiltonian Dynamics: Generalized momentum and cyclic coordinates, Hamiltonian, Hamilton's canonical equations of motion, Hamilton's canonical equations of motion in different co-ordinate systems, Applications of Hamiltonian's equation of motion. Hamiltonian for a charged particle in an electromagnetic field, Principle of least action, Canonical transformations. Legendre transformation, Generating function, Infinitesimal contact transformation, Jacobi's identity, Lagrange's brackets, The angular momentum and Poisson brackets, Hamilton's equation in terms of

Poisson's brackets, Poisson bracket in Quantum Mechanics, Phase space and the motion of the system, Liouville's theorem, Hamilton-Jacobi method, H-J equation for Hamilton's characteristic function, Application of H-J method: Solution of one dimensional harmonic oscillator, Action and angle variables

Section A

Motion under Central Force: Equivalent one body problem, General features of central force motion, Equivalent one dimensional problem-features of orbits, Inverse square law-Kepler problem, Virial theorem, Rutherford scattering, Center of mass and Laboratory co-ordinates, Transformation of scattering problem to laboratory co-ordinates.

Four dimentional formulation-Minkowski space: Four vectors and its applications, Lagrangian and Hamiltonian formulation of relativistic mechanics, Covariant Lagrangian and Hamiltonian formulation.

Recommended Books:

1. Goldstein, H. (1980*). Classical Mechanics*, Addison-Wesley.
2. Sommerfeld, A. (1952). *Lectures on Theoretical Physics: Mechanics*. Academic Press
3. Upadhyaya J. C. (2003). *Classical Mechanics*, (Himalaya Publishing House)

Suggested web-resources:

1. https://nptel.ac.in/courses/115103034/#
2. https://nptel.ac.in/courses/11510606/

PHY 404 Mathematical Physics

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

After completed this course, Student will be able to :

- have a good grasp of the basic elements of complex analysis, including the important integral theorems.
- Student will be able to determine the residues of a complex function and use the residue theorem to compute certain types of integrals.
- be able to solve ordinary second order differential equations important in the physical sciences; solve physically relevant partial differential equations using standard methods like separation of variables, series expansion (Fourier-type series) and integral transforms.

- have learned how to expand a function in a Fourier series, and under what conditions such an expansion is valid. Student will be aware of the connection between this and integral transforms (Fourier and Laplace) and be able to use the latter to solve mathematical problems relevant to the physical sciences.

Section A

Tensor: Introduction, rank and number of components of a tensor, contravariant and covariant tensors, transformation of covariant, contravariant and mixed tensors, addition, multiplication and contraction of tensors. Metric tensor, Coordinate transformation and Jacobian.

Complex Analysis: Function of complex variable, derivative and the Cauchy-Riemann differential equations, analytic function, line integral of complex function, Cauchy's integral theorem, Cauchy's integral formula, Taylor's and Laurent series, Cauchy's residues theorem, singular points of an analytic function, evaluation of residues, Liouville's theorem, evaluation of definite integrals.

Section B

Ordinary Differential Equations: Second-order homogeneous and nonhomogeneous differential equations with constant and variable coefficients.

Special Functions: Series solution method, solutions and basic properties like orthogonality, recurrence relations, graphical representation and generating functions of Bessel's, Hermite's Legendere's, Laguerre's and associated Legender functions.

Second-order partial differential equations: Laplace, Poisson, Helmholtz, Wave and Diffusion equations.

Section C

Integral transforms: Laplace transforms - first and second shifting theorems, inverse Laplace transform-first and second shifting theorems, Laplace transform and inverse Laplace transform of derivative and integral of function, Convolution theorem.

Fourier series - Fourier series of arbitrary period, Summation of the Fourier series.

Fourier Transform - Fourier sine and cosine transform, inversion formula for Fourier sine and cosine transforms, change of scale property, shifting theorem, multiple Fourier transform, Convolution theorem, Fourier transform of the derivatives of a function.

Recommended Books:

1. Das, H. K., Verma, R (2014), *Mathematical Physics*, S. Chand and company.
2. Rajput B S, (2005), *Mathematical Physics* Pragati Prakashan.
3. Kreyszig E. (2015), *Advanced Engineering Mathematics*, John-Wiley.
4. Weber, H. J., & Arfken, G. B. (2003). *Essential Mathematical Methods for Physicists,* ISE. Elsevier.
5. Gupta B.D., (2010), *Mathematical Physics*, Vikas Publishing House Pvt. Ltd.

Suggested web-resources:

https://nptel.ac.in/courses/115103036/#

https://nptel.ac.in/courses/115106086/

PHY 406 Quantum Mechanics – I

	L	T	P	C
Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

Students who complete this course should

- Have a deep understanding of the mathematical foundations of quantum mechanics.
- Be able to solve the Schrodinger equation for simple configurations.
- Understand the effect of symmetries in quantum mechanics.

Section A

Why Quantum Mechanics? The quantum concept, Postulates of quantum mechanics Schrodinger equation: Derivation and Solution, Physical interpretation of wave function, Expectation values, Probability current density, Ehrenefest's theorem, Uncertainty principle, Complementarity principle.

One-dimensional problems: Wells and barriers, Harmonic oscillator by Schrodinger's equation, Applications of Schrodinger equation in Spherical Symmetric System: Rigid Rotator and Hydrogen Atom, Degeneracy.

Section B

Operators in QM: Orthogonal sets, Completeness, Different type of operators, Eigen values and Eigen functions, Operator formalism in QM, Commutation Algebra, Commutativity and simultaneous eigen functions.

Hilbert space, Operators as matrix, Matrix form of wave function, Schrodinger, Heisenberg and Interaction matrix representation, Dirac's Bra and Ket vectors, Direct sum and product of Hilbert space, Co-ordinate and momentum representation.

Identical particles, Symmetric and anti-symmetric wave functions, Particle exchange operator, Pauli exclusion principle, Spin angular momentum, Stern-Gerlach experiment, Spin matrices for electron, Commutation relations.

Section C

Angular momentum operator, Spin angular momentum, Total angular momentum operators, Commutation relations of total angular momentum, Eigen values of J_2 and J_z, J_+ and J_-, J_x and J_y, Addition of angular momenta, CG coefficients, Wigner-Eckart theorem.

Approximate method- Time independent perturbation theory, Non-degenerate and degenerate cases, Applications: – normal He atom, perturbed harmonic oscillator, Zeeman effect and Stark effect.

Recommended Books:

1. Schiff L. I.; Quantum Mechanics- III ed., (1968) Mcgraw-Hill
2. Ghatak, A.K. and Lokanathan, S.; *Quantum Mechanics Theory and Applications* (1997), Macmillan India Limited – IIIrd Ed.
3. Das, A and Milissionos, A.C.; *Quantum Mechanics: A modern approach* (1992) Gordan and Breach Science Publishers.
4. Grenier, W.; *Quantum Mechanics An Introduction* (1994) Springer – IIIrd Ed.
5. Sakurai, J.J; *Modern Quantum Mechanics* (1999) Addison-Wesley
6. Eisberg, R and Resnick, R.; *Quantum Physics* (atoms, molecules…) John Wiley and Sons

Suggested web-resources:

https://nptel.ac.in/courses/115106066/

https://nptel.ac.in/courses/115103104/

ELE 406 Principles of Digital Electronics

Max. Marks : 100	**L T P C**
(CA: 40 + ESA: 60)	**4 0 0 4**

Learning Outcomes:

After successfully completed course, Student will be able to :

- Understand the fundamentals of the digital electronics
- Understand the Boolean algebra and number system that forms the basics of any electronic device.
- Sequential logic circuits and their operations

Section A

Number system (binary, octal, decimal, hexadecimal) bits & bytes, representation of integers, real, positive and negative numbers. Binary Arithmetic, Simple concept of theorems of Boolean Algebra.

Representation of characters: BCD, ASCII, EBCDIC Codes. Weighted codes, self complementary codes, Error detecting codes and error correcting codes (Parity, Gray, Hamming codes).

Logic Gates : Logic Gates and Boolean Algebra Representation and Simplification of functions by Karnaugh Maps. Combinational Circuits design. Combinational circuits - adder, subtractor, decoder, demultiplexer, encoder, multiplexer, comparator.

Section B

Sequential Logic Circuit & Design - flip flop, shift register, asynchronous and synchronous counters.

Digital Logic Families and Their Charactersistic : RTL, DTL, TTL, Schotlky TTL, ECL, MOS and CMOS, Fan in, Fan out.

Section C

Semiconductor Memories : RAM, ROM, PROM, EPROM, BJTRAM Cell, MOS RAM Cell, Organization of RAM, Charge Coupled devices (CCD), storage of charge and transfer of charge in CCD.

D/A Converter : Weighted resistance D/A, R-2R Ladder Converter. DAC 0800 D/A Chip, D/A Converter specification.

A/D Converter : Analog to Digital Converter, Parallel Comparator Converter, Counting Converter, Successive Approximation Converter, Dual Slop converter A/D converter specification, sampling and hold circuit, ADC 0804 Converter chip.

Text/Reference Books:

1. Malvino C. P. and Leach D. P; (1985), Digital Principles and Applications, McGraw Hill.
2. Mano M. M.; Digital logic and computer design, Tata McGraw Hill.
3. Taub and Shilling; Digital Integrated Circuits, Tata McGraw Hill
4. Hayes J. P.; (1988) Computer Architecture and Organization, McGraw Hill.
5. Floyd; Digital Fundamentals, McGraw Hill.
6. Botkar K. R.; Digital Ic, McGraw Hill.

Suggested web-Resources:

1. https://nptel.ac.in/courses/115103046/#
2. https://nptel.ac.in/courses/115106066/

ELE 406L Principles of Digital Electronics Lab

	L	T	P	C
Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

After successfully completed course, Student will be able to :

- Have hand on experience of electronic circuits on bread board
- Design complex electronic circuits on bread board using different ICs

List of Experiments:

1. The study & verification of various parameters of active & passive component.
2. To verify the truth table of various logic gates (AND, OR, NOT, NOR, NAND, XOR)
3. Verify the various theorems of Boolean algebra.
4. Verify the D'morgans theorem.
5. Implement the Boolean expression and verify the truth table.
6. Design the various combinational circuits-Half Adder, Half subtractor, Full Adder, Full subtractor, Parity Generator' Parity Checker.
7. Design the advanced combination circuits-Multiplexer, Demultiplexer, Encoder, Decoder.
8. Design the various code converters & verify the truth table-Binary to BCD converter, Binary to Gray codes and Binary to EX-3.

9. Design the weighted code converter.
10. Design the flip flops and verify the truth table-R-S,D,J-K, T and Master slave.
11. Design the various registers using flip-flop-Serial in Serial out, Serial in Parallel out, Parallel in Parallel out, Parallel in Serial out
12. Design the various synchronous counters using flip-flop-Binary up, Binary down, Mod-10.
13. Design the various asynchronous counters using flip flop- Binary up, Binary down.
14. Design the special counters-Ring counter and Twisted ring counter (Johnson counter).
15. To study the A/D & D/A converters also calculate resolution & error percentage in observation.
16. To design an Astable Multivibrator using 555 Timer.
17. To design an Bistable Multivibrator using 555 Timer.
18. To design an Monostable Multivibrator using 555 Timer.

CS 416 Computer Programming

	L	T	P	C
Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

After completion of this course the student will be able to :

- Learn fundamental of computers and operating systems
- Learn basic languages and their coding
- Develop good programming skills using algorithms and flowcharts.
- Coding programs in ‘C’ using data types, control structures, functions arrays and pointers.
- Demonstrate the ability to run, test, and debug ‘C’ programs.

Section-A

Simple Model of a Computer System: CPU, Memory, Input/Output Devices. Hardware and Software, Booting Process and DOS Command. Steps Involved in computer programming, problem analysis, algorithms & flow charts. Computer programming (in C) : Various data types (simple and structured) and their representation, constants and variable, arithmetic’s and logical expressions, data assignment, input and output statement. High level and low level programming language.

Section-B

C Programming: Control statement- sequencing, conditional and unconditional branching and looping. Single and multi-dimensional arrays. Searching (Linear, binary), sorting (bubble, selection and insertion) and merging.

Section-C

Pointer, address arithmetic. Function, Parameter passing, recursion. Dynamic memory allocation. Structure and union, file handling, command line arguments.

Recommended Books:

1. Kanetkar, Yashavant P., Let us C, BPB Publications
2. Sinha, P. K., *Computer fundamentals: concept, systems and application*, BPB

Reference Books:

1. Kernighan, Brain W., *The C .programming language*. Prentice - Hall
2. Kanetkar, Yashavant P., *Understanding pointers in C*, BPB Publications
3. Dromey, R. G., *How to solve it by computer*, Prentice- Hall
4. Govil, Mahesh Chand, *Computer fundamentals and programming in C*, Jaipur Pub. House
5. NUT, *Introduction to computer programming*, Prentice-Hall
6. Venugopal, K. R., *Programming with C*, Tata Mcgraw Hill
7. Balagurusamy, E., *Programming in ANSI C*, Tata McGraw-Hill

CS 416L Computer Programming Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**8**	**4**

Learning Outcomes:

After completion of this course the student will be able to :

- Learn various commands.
- Learn basic languages and their coding.
- Develop good programming skills using algorithms and flowcharts.

Lab Number	Problems
Ll-L3	Simple hand? on computers and DOS Internal & External Commands
L4-L6	Simple Problems Using scant' and printf functions. Formula Based Problems using Constants, Variables and use of operators.
L7-L8	Use of Library Functions e.g. sqrt, sin, cos, log etc.
L9-L20	Loop Statement using for, while, do -while statement
L21-L25	Conditional Checking Using if statement, Nested if statement, switch statement and Unconditional goto
L26-L40	Problems based on array data types. Problems on One Dimensional Array-Searching (Linear, Binary), Sorting (Bubble, Selection, Insertion), Merging.
L41-L45	Problems on two Dimensional Array -Matrix Operation: Addition, Subtraction, Multiplication etc.
L46-L50	Problems based on pointers. Parameter passing in functions. Recursion
L51-L55	Declaration, Reading, Writing and manipulation on struct and union data type
L56-L62	File handling
L63-L64	Command line Arguments

Second Semester

PHY 401 Atomic and Molecular Physics

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

After completion of this course the student will be able to :

- Be able to understand about the transitions occur in the materials.
- Understand the basic principles of spectroscopy where electromagnetic radiation interacts with matter and their results.

Section A

One electron atom, Electron spin and Vector model, Pauli's principle, Spin orbit interaction, Hydrogen fine structure, He atom and its spectrum, Multi-electron atoms – Hartree's field theory, Spectroscopic terms: L-S and J-J couplings, Normal and anomalous Zeeman effect, Paschen back effect, Stark effect.

Section B

Spectra of Alkali elements, Spectra of Alkaline earth elements, Hyperfine structure of spectral lines, Line broadening mechanism (general idea), X-ray spectra, Kossel's explanation of characteristic of X-ray spectra, Mosley law, Absorption spectra, Fine structure and doublets in X-ray spectra.

Section C

Molecular energy states and molecular spectra, Types of molecular spectra, Rigid rotator, Rotational energy levels of diatomic molecules, Rotational spectra, Vibrational energy levels of diatomic molecules, Pure rotational spectra, Vibrational-Rotational spectra, Electronic spectra: Frank-Condon Principle, Raman spectra.

Recommended Books:

1. White H. E. (1934) Introduction to atomic spectra (Mc-Graw Hill)
2. Kumar R (1997) Atomic and molecular spectra (Kedad Nath Ram Nath Publication)

Suggested web-resources:

https://nptel.ac.in/courses/115101003/

PHY 402 Classical Electrodynamics-I

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

After completion of this course the student will be able to :

- Have deep understanding about the scientific, mathematical and engineering principles that enable them to understand forces, fields, and waves.
- Learn the functioning of the devices that work on those principles and phenomena.

Section A

Electrostatics: Electric field, Gauss law, Differential form of Gauss law, and the scalar potential, surface distribution of charges and dipoles and discontinuities in the electric field and potential, Poisson and Laplace equations, Green's Theorem, Uniqueness of the solution with Dirichlet or Neumanm Boundary conditions, Formal solution of electrostatic Boundary value problem with Green's Function, Electrostatic potential energy and energy density.

Boundary-Value Problems in Electrostatics: Methods of Images, Point charge in the presence of a grounded conducting sphere, Point charge in the presence of a charged insulated conducting sphere, Point charge near a conducting sphere at fixed potential, conducting sphere in a uniform electric field by method of images.

Section B

Multipoles, Electrostatics of Macroscopic Media Dielectrics: Multipole expansion, multipole expansion of the energy of a charge distribution in an external field, Elementary treatment of electrostatics with permeable media, Boundary value problems with dielectrics; Molar polarizability and electric susceptibility, Models of molecular polarizability, Electro-static energy in dielectric media, capacitance, dielectrics,

Magnetostatics : Introduction and definition, Biot and Savart law, the differential equations of magnetostatics and Ampere's law, Vector potential and Magentic induction for a circular current loop, Magnetic fields of a localized current distribution, Magnetic moment, Force and torque on and energy of a localized current distribution in an external magnetic induction, Macroscopic equations, Boundary conditions on B and H.

Section C

Time varying fields Conservation Laws and Relativistic Electrodynamics: Energy in a magnetic field, Vector and Scalar potentials, Gauge transformations, Lorentz gauge, Coulomb gauge, Poynting theorem and conservation of energy and momentum for a system of charged particles and EM fields, Conservation laws for macroscopic media.

Mathematical properties of the space-time, special relativity, Invariance of electric charge covariance of etectrodynamics, Transforniation of electromagnetic fields, Electromagnetic field tensor, Transformation of four potentials and four currents, Tensor description of Maxwell's equation.

Recommended Books:

1. Jackson J. D., (2012) Classical electrodynamics (Wiley, India).
2. Panofsky & Philips (2006) *Classical Electricity and Magnetism, Sarat Book house, New Delhi.*
3. Griffiths, D. J. (2005) *Introduction to Electrodynamics* (Pearson Education).
4. Landau & Lifshitz, (1960) *Classical theory of Electrodynamics* (Pergaman Press, New York).
5. Landau & Lifshitz, (1960) *Electrodynamics of Continuous media* (Pergaman Press, New York).
6. Sadiku M. N. O. (1999) *Elements of Electromagnetics* by (Oxford Univ. Press).

Suggested web-resources: -

https://nptel.ac.in/syllabus/115101005/

https://ocw.mit.edu/courses/findbytopic/#cat=science&subcat=physics&spc=electromagnetism

PHY 405L Physics Lab - I

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**8**	**4**

Learning Outcomes:

After completing of this course, Student will:

- Be able to demonstrate spectra of some specific elements
- Be able to understand and demonstrate the effect of external field on the spectral lines
- Be able to handle useful equipments related to spectroscopy

List of Experiments:

1. To study the hyperfine structure of spectral lines and Zeeman effect by C.D.S.
2. To study the absorption spectrum of Iodine vapour.
3. To determine the Rydberg's constant with the help of Spectrometer.
4. To study the variation of refractive index of the material of the prism with wavelength and to verify Cauchy's dispersion formula.
5. To determine the wavelength of Sodium light by Michleson Interferometer.
6. To determine the difference between two lines of Sodium light by Michleson Interferometer.
7. To determine the refractive index of glass by Michleson Interferometer.
8. To verify Hartmann's Formula using constat deviation spectrograph.
9. To determine wavelength of Monochromatic light using Fabry-Perot interferometer.

10 To determine g-factor by ESR setup.

11 To study Frank Hertz experiment i.e. variation of accelerating voltage with electron beam current.

PHY 407 Quantum Mechanics – II

	L	T	P	C
Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

After completing of this course, Student will:

- Have a deep understanding of the various approximate methods of quantum mechanics
- Be able to solve the scattering problem through quantum mechanical consideration.

Section A

Approximation Methods: Recap of perturbation theory, motivation of approximation methods, Variational methods, WKB Approximation, Applications of Variational and WKB methods. Time dependent perturbation theory, Harmonic perturbation, Fermi's Goldenrule, Transition probabilities, Adiabatic and sudden approximation, Aharonov-Bohm Effect, Semiclassical treatment of radiation.

Section B

Quantum Theory of Scattering: Collision in 3-D and scattering, Laboratory and CM reference frames, Scattering amplitude, Differential scattering cross section and total scattering cross section, General formulation of scattering theory, Born approximation, Applications of Born approximation, Partial Wave Analysis and Phase Shift, Applications of PWA, The Lippmam-Schwinger equation.

Section C

Relativistic Quantum Mechanics: Requirement of relativistic quantum theory, Four vector notation, Klein-Gordon Equation, Solution of Klein-Gordon equation, Dirac's relativistic equation, Solution of Dirac's Equation, Non-relativistic correspondence and concept of spin, Covariance of Dirac equation, Foldy-Wouthuysen transformation, Relativistic Hydrogen Atom problem, Hole theory of fermions, Time reversal and other symmetries.

Recommended Books:

1. Ghatak, A. & Lokanathan S. (2001) *Quantum Mechanics* (McMillan India Ltd.)
2. Sakurai J. J. (2005) *Modern Quantum Mechanics* (Pearson Education)
3. Griffiths D. (2006) *Introduction to Quantum Mechanics* (Pearson Education)
4. Bjorken J. D. and S. D. Drell (1997) *Relativistic Quantum Mechanics* (McGraw Hill)
5. Greiner,W and Bromley D. A. (2003) *Relativistic Quantum Mechanics* (Springer)

Suggested web-resources:

https://nptel.ac.in/courses/115102023/

https://nptel.ac.in/courses/122106034/

https://ocw.mit.edu/courses/physics/8-322-quantum-theory-ii-spring-2003/

PHY 408 Statistical Mechanics

Max. Marks : 100	**L T P C**
(CA: 40 + ESA: 60)	**4 0 0 4**

Learning Outcomes:

After completing of this course, Student will:

- Have a deep understanding of physical statistics and its relation to information theory
- Be able to solve statistical mechanics problems for simple non-interacting systems
- Have a basic understanding of the phase transitions,
- Be able to use linear response theory and kinetic equation approach

Section A

Foundations of Statistical Mechanics, Specification of states of system, Contact between statistics and thermodynamics, Classical ideal gas, Entropy of mixing and Gibb's paradox.

Microcanonical ensemble, Phase space, Trajectories and density of states, Liouville's theorem, Canonical and grand canonical ensembles, partition function, calculation of statistical quantities, Energy and Density fluctuations.

Section B

Density matrix, Statistics of ensembles, Statistics of indistinguishable particles, Maxwell-Boltzman, Fermi-Dirac and Bose-Einstein statistics, Properties of ideal Bose and Fermi gases, Bose-Einstein condensation.

Expansion of classical gas, Virial equation of state, Ising model, mean-field theories of ising model in one dimensions, Exact solutions in one dimension.

Section C

Landau theory of phase transition, Critical indices, Scale transformation and dimensional analysis, Correlation of space-time dependent fluctuations, Fluctuations and transport phenomena, Brownian motion, Langevin theory, fluctuation dissipation theorem, The Fokker-Planck equation.

Recommended Books

1. Reif, F., (1985) *Fundamentals of statistical and thermal physics* (Mc Graw Hill).
2. Landau and Lifshitz (2005*) statistical physics* (Butterworth-Heinemann Oxford)
3. Huang K. (2004) *statistical physics* (John Willey)
4. Pathria R. K. (2005) *statistical mechanics* (Elsevier)

Suggested web-resources:

https://nptel.ac.in/courses/115103028/

https://ocw.mit.edu/courses/physics/8-044-statistical-physics-i-spring-2013/

TSKL 404 Communication Skills

Max. Marks : 100	**L T P C**
(CA: 40 + ESA: 60)	**2 0 0 2**

Learning Outcomes:

After completing of this course, Student will:

- Develop communicative competence and critical thinking abilities.
- Appraise the importance of effective communication in their respective professions.
- Improve interpersonal skills which will enhance their presentation skills.
- Learn and apply the knowledge of report writing in formal situations.
- Prepare CV/Resume so as to highlight accomplishments while applying for jobs.
- Develop effective writing process to compose different types of formal communication.

Course Content

Section I

Communication : Meaning, Nature, Types, Models, Purpose, Barriers and Remedies. Body Language

Section II

Letter and Email Writing: Official Formal Letter, Types of Letters: Sales, Order, Enquiry, Complaint and Adjustment. Email Writing: Features, Etiquette Drafting Circular, Agenda, Minutes and Inter-Office memorandum CV/Resume Writing: Applying for a job. Letter of

Application. Recommendation/Reference letters (Seeking and Giving), Acceptance and Resignation letters.

Section III

Report Writing: Definition, Scope, purpose ,types, sections. Report Planning, Collecting Information and developing an outline. Mechanics of Writing. Comprehension/Reading : Scan, Browse and Skim for information.

Comprehension passages for Vocabulary and Patterns (SV,SVC,SVOA,SVOC,SVOO,SVA,SVO)

Recommended Books:

1. Bovee, C., L., John V. Thill and Barbara E. Schatzman. (2004). *Business Communication Today*: *Seventh Edition.* Delhi: Pearson Education.
2. Diwan, P. (2004). *Effective Business Communication*. New Delhi: Excel Books.
3. Kaul, A. (2014). *Effective Business Communication*, New Delhi: PHI Learning Pvt. Ltd.
4. Lesikar, R. V. and John D. Pettit. (1998). *Report Writing for Business*. Boston: McGraw-Hill.
5. Lesikar, R. V and Marie E. Flatley. (2002). *Basic Business Communication: Skills for empowering the Internet Generation: Ninth Edition.* New Delhi: Tata McGraw-Hill Publishing Company Ltd.
6. Pease, A. and Barbara Pease. (2005). *The Definitive Book of Body Language*. New Delhi: Manjul Publishing House.
7. Rupesh, J. and Weldon Kees.(1996). *Nonverbal Communication: Notes on Visual Perception of Human Relations*. Berkeley: University of California Press.
8. Sharma R.C. and Krishan Mohan. (2007) *Business Correspondence and Report Writing*. New Delhi: Tata Mc Graw Hll.

Suggested e-resources

https://www.olmsteadassoc.com/resource-center/

http://www.bristol.ac.uk/arts/exercises/grammar/grammar_tutorial/index.htm

https://grammar-monster.com/

https://www.myenglishteacher.eu

http://www.people-communicating.com/

CS 414 Computer Oriented Numerical and Statistical Methods

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

On successful completion of the course, Student will be able to:

- Apply numerical methods to obtain approximate solutions to mathematical problems.
- Using appropriate numerical methods, determine the solutions to given non-linear equations, systems of linear equations, interpolation, numerical differentiation and integration and numerical solution of ordinary differential equations.
- Analyze the errors obtained in the numerical solution of problems.
- Apply appropriate algorithms to solve selected problems, both manually and by writing computer programs.
- Compare different algorithms with respect to accuracy and efficiency of solution.
- Implement numerical methods algorithm using programming language.

Section A

Errors and Approximations in Digital Computers, Number representation, Floating point Arithmetic. Solution of systems of linear equations - direct method, Gauss Jordan & Gauss Elimination methods, Pivoting, Iterative methods - Jacobi & Gauss Seidel method.

Solution of Nonlinear equations in n variable : Localization of the roots, Bisection and Regula - Falsi methods, Newton-Raphson method, successive Approximation method, Rate of convergence and Aitkin's process.

Section B

Interpolation: Newton's Interpolation formulae - Forward and Backward difference formulae, Derivatives & tabulated functions, Lagrange's Interpolation formula.

Numerical Integration and Differentiation: Newton-Cotes formulae - Trapezoidal & Simpson's rule, change of interval of integration, Numerical Differentiation, derivatives from Newton-Goegory Forward Polynomial.

Numerical solution of ordinary Differential equations: ODE's, a system of first order ODE's, Euler's, Picards and Taylor series methods of real functions - Introduction and Polynomial Approximations, Least squares approximation.

Section C

Statistical Methods: Treatment of data, Frequency Distribution, measures of central tendency, dispersion & partition values.

Probability distribution - Binomial, Poisson & Normal.

Curve fitting by principle of least square, Correlation and regression.

Inference- Tests of significance for mean, variance, proportion, and correlation coefficient, Test of goodness of fit and independence of attributes. Analysis of variance for one way classified data.

Recommended Books:

1. Rajaraman, V. (2018) Computer Oriented Numerical Methods, PHI learning.
2. Sastry, S. S. (2012). *Introductory methods of numerical analysis*. PHI Learning Pvt. Ltd..
3. Gupta, S. P. (1994). *Statistical Methods*, Sultan Chand & Sons, New Delhi
4. Gupta, S. C., & Kapoor, V. K. (1997). *Fundamentals of Mathematical Statistics*, Ninth Extensively.Revised Edition, Sultan Chand & Sons.

Reference Books:

1. Grewal, B. S. (2018). Numerical Methods in Engineering and Science:(C, and C++, and MATLAB). Stylus Publishing, LLC.
2. Krishnamurthy, E. V., & Sen, S. K. Numerical Algorithms: Computations in Science and Engineering. 2001. Affiliated East-West Press, New Delhi.
3. GovilR., *Kamputer se sankhyatmakReetiyan*, et.al. Pitamber Publications, New Delhi
4. Krishnamurthy, E. V., & Sen, S. K. (1976). *Computer-based numerical algorithms*.East-West Press.
5. Rao, K. S. (2017). *Numerical methods for scientists and engineers*. PHI Learning Pvt. Ltd..
6. Yule, G. U., & Kendall, M. G. (1987). *An Introduction to the Theory of Statistics* Universal Book Stall. *New Delhi*.
7. Agarwal, B. L. (2006). *Basic statistics*.New Age International.

8. Govil R. *Kamputer se sankhyatmakReetiyan*, et.al. Pitamber Publications, New Delhi

Suggested web-resources:

https://nptel.ac.in/courses/122106033/

CS 414L Computer Oriented Numerical and Statistical Methods Lab

Max. Marks : 100 **L T P C**
(CA: 40 + ESA: 60) **0 0 4 2**

Learning Outcomes:

On successful completion of the course, Student will be able to:

- Apply numerical methods to obtain approximate solutions to mathematical problems related to physics
- Use appropriate numerical methods, determine the solutions to given non-linear equations, systems of linear equations, interpolation, numerical differentiation and integration and numerical solution of ordinary differential equations.
- Analyze the errors obtained in the numerical solution of problems.
- Apply appropriate algorithms to solve selected problems, both manually and by writing computer programs.
- Compare different algorithms with respect to accuracy and efficiency of solution.

Lab No.	**Problems**
L01	Perform floating point operations using normalization (addition, subtraction, multiplication, division)
L02-L03	Find the roots of equation (bisection method, regula-falsi method, Newton raphson method, secant method, successive approximation method)
L04-L05	Find solution of n linear equation (Gauss elimination method (with & without pivoting). Gauss Seidel method. Gauss Jordan method
L06	Generate following difference tables (forward, backward, divided difference)

L07-L09	Interpolate value of f(x) at given x (Lagrange's interpolation method, Newton forward interpolation method, Newton's backward interpolation method), Inverse interpolation
L10-L11	Fitting of different curves (straight line fit (x on y), straight line fit (y on x), parabola, geometric curve, exponential curve)
L12- L13	Find derivative of a given tabulated function at given value (Newton's forward method, Newton's backward method)
L14 – L16	Find Integrated value, (when tabulated function given-Trapezoidal rule (simple & modified), Simpson's 1/3 (simple & modified), Simpson's 3/8 (simple & modified)
L17 – L19	Find Integrated value, when algebraic expression given (when algebraic expression given-Trapezoidal rule (simple & modified), Simpson's 1/3 (simple & modified), Simpson's 3/8 (simple & modified).
L20-L21	Solve differential equation (Euler's method, Runge-Kutta 2nd order method, Runge-kutta 4th order method. Modified Euler's method, Predictor-corrector method.
L22-L23	Determination of Mean, Median, Mode, G.M., H.M., Quartiles, Deciles and Percentiles.
L24-L25	Computation of Range, Standard deviation, Mean deviation, Quartile deviation and Coefficient of variation.
L26	Computation of coefficients of correlation and rank correlation.
L27-L28	Fitting of (i) Binomial, (ii) Poisson
L29	Test of Significance problems for Large sample testing
L30-L31	Chi Square test for goodness of fit and independence of attributes
L32	ANOVA for one way classification.

Third Semester

PHY 504 Classical Electrodynamics-II

	L	T	P	C
Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

After completion of this course the students will be able to:

- Understand the fundamentals of electromagnetic phenomena whenever the relevant length scales and field strengths are large enough that quantum mechanical effects are negligible.
- Have deep understanding about the scientific, mathematical and engineering principles that enable them to understand forces, fields, and waves.

Section A

Plane Electromagnetic Waves and Wave Equation : Plane wave in a nonconducting medium, Frequency dispersion characteristics of dielectrics, conductors and plasmas, waves in a conducting or dissipative medium, superposition of waves in one dimension, group velocity, causality connection between D and E, Kramer-Kronig relation.

Magnetohydrodynamics and Plasma Physics : Introduction and definitions, MHD equations, Magnetic diffusion, viscosity and pressure, Pinch effect, instabilities in pinched plasma column, Magnetohydrodynamic waves, Plasma oscillations, short wave length limit of plasma oscillations and Debye shielding distance.

Section B

Radiation by moving charges : Lienard-Wiechert Potentials for a point charges, Total power radiated by an accelerated charge: Larmour's formula and its relativistic generalization, Angular distribution of radiation emitted by an accelerated charge, Radiation emitted by a charge in arbitrary extremely relativistic motion, Distribution in frequency and angle of energy radiated by accelerated charges, Thomson scattering and radiation, Scattering by quasifree charges, coherent and incoherent scattering, Cherenkov radiation,

Section C

Radiation damping, self fields of a particle, scattering and absorption of radiation by a bound system : Introductory considerations, Radiative reaction force from conservation of energy, Abraham Lorentz evaluation of the self force, difficulties with Abraharn Lorentz model, Integro-differential equation of motion including radiation damping, Line Breadth and level shift of an oscillator, Scattering and absorption of radiation by an oscillator, Energy transfer to a harmonically bound charge.

Recommended Books:

1. Jackson J. D., (2012) *Classical electrodynamics* (Wiley, India).
2. Panofsky & Philips (2006) *Classical Electricity and Magnetism*, (Sarat Book house, New Delhi).
3. Griffiths, D. J. (2005) *Introduction to Electrodynamics* (Pearson Education).
4. Landau & Lifshitz, (1960) *Classical theory of Electrodynamics* (Pergaman Press, New York).
5. Landau & Lifshitz, (1960) *Electrodynamics of Continuous media* (Pergaman Press, New York).
6. Sadiku M. N. O. (1999) *Elements of Electromagnetics* by (Oxford Univ. Press).

Suggested web-resources: -

https://nptel.ac.in/syllabus/115101005/

https://ocw.mit.edu/courses/find-by topic/#cat=science&subcat=physics&spec=electromagnetism

PHY 516 Nuclear Physics-I

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

After completion of the course the student will be able to:

- Understand the concept of nuclear physics.
- Understand the structure of matter at the atomic level.
- Understand the interactions of the atom molecules and the building blocks.
- Understand the nuclear power generation and nuclear weapons technology.

Section A

Nuclear Properties: Radius, mass, angular momentum, magnetic moment, electric quadrupole moment, parity and binding energy.

Two nucleon system and Nuclear forces: General nature of the force between nucleons, saturation characteristic of nuclear forces, charge independence, spin dependence, concept of exchange forces, Yukawa theory (only qualitative description), general form of two nucleon interaction, central, non-central and velocity dependent potentials. Analysis of ground state of Deuteron using square well potential, range-depth relationship, excited state of Deuteron, discussion of ground state of Deuteron under non-central forces, calculation of electric quadrupole moment and magnetic dipole moment and the d-state admixture.

Section B

Nucleon-Nucleon scattering: Neutron-proton scattering at low energy assuming square well central potential, qualitative discussion in terms of partial wave, concept of scattering length, coherent scattering of nutron by proton in Ortho and Para Hydrogen molecules, the effective range theory in neutron-proton scattering and shape independence of nuclear potential, qualitative discussion of proton-proton scattering at low energy, general features of two nucleon scattering at high energy and effect of exchange forces.

Interaction of radiation and charge particle with matter: Law of absorption, attenuation coefficient for photo-electric effect, Compton scattering, pair production, energy loss of charged particle due to ionization and Brehmstrahlung, range energy curve and the straggling, interaction of Neutron with matter.

Section C

Experimental techniques:

Nuclear detector: Gas-filled counters, Neutron detector, Neutron time of flight method, Scintillation and Cherenkov counters, solid state detectors, nuclear emulsions, techniques of measurement and analysis of tracks, electronic circuits used with typical detectors.

Particle accelerator: Linear accelerator, cyclotron,, syncro-cyclotron, betatron, electron-syncrotron, proton syncrotron

Recommended Books:

1. Kaplan I. (1992) *Nuclear Physics* (Addison Wesley Pub. Co.).
2. Roy R. R. and Nigam B. P. (1997) *Nuclear Physics Theory and Experiment* (New Age Internation Pub.).

3. Evans R.D. (1965) *Atomic Nucleus* (McGraw Hill).
4. Ghoshal S. N. (2006) *Nuclear Physics* (S. Chand, New Delhi),
5. Singru R. M. (1972) *Introduction to Experimental* Nuclear Physics (Wiley Eastern pvt. Ltd.)
6. Patel S. B. (1992) *Nuclear Physics: an Introduction* (Wiley Eastern Ltd.).

Suggested web-resources:

https://nptel.ac.in/courses/115104043/

https://nptel.ac.in/courses/115103101/

PHY 538 Physics of Lasers and Laser Applications

	L	T	P	C
Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

After completion of this course the student will be able to:

- Understand the mechanism of the laser
- Apply lasing phenomena in opto-devices
- Understand the applications of laser in various fields

Section A

Idea of laser, Spatial and Temporal Coherence, Spontaneous and Stimulated emission, Population inversion, Pumping Techniques: Direct and Indirect Pumping; Optical Pumping; Particle Pumping; Electrical Pumping, Laser Rate equations for 2,3 and 4 level laser systems, Threshold for 3 and 4 level laser systems

ABCD Matrices, Stable and Unstable Optical Resonators, Gaussian beam and its properties, Longitudinal and Transverse modes of laser cavity

Section B

Q-switching, Mode locking, Pulse shortening: nano, pico and femtosecond operation.

Carbon dioxide laser, X-ray laser, Dye laser, Nd : YAG and Nd : Glass laser,Ti:Sapphire Laser, Fiber laser, Semiconductor laser, Quantum-well laser.

Section C

Laser Induced Fluorescence,

Nonlinear Raman spectroscopy: Stimulated Raman scattering; CARS, Hyper Raman effect, SERS; Resonance Raman effect,

Laser induced multiphoton process: two photon and three photon absorption,

Saturation Spectroscopy: Hole Burning; Lamb Dip; Experimental Schemes; Cross over signals,

Medical, Engineering, Civil and defense applications of Lasers

Text/Reference Books:

1. Silfvast W. T. (1998) *Laser Fundamentals* (Cambridge University Press).
2. Ghatak A. and Thyagarajan K. (2006) *Optical Electronics* (Cambridge University Press).
3. Ghatak A. and Thyagarajan K. (2010) *Lasers* (Cambridge University Press)
4. Svelto O. (1998) *Lasers* (Springer Science Inc., USA).
5. Demtroder W. (2003) *Laser Spectroscopy* (Springer-Verlag).
6. Wilson J. and Hawkes J.F.B. (1989) Optoelectronics*: An Introduction* (Prentice Hall International (UK) Limited).
7. Gupta S.C. (2005) *Optoelectronic Devices and Systems* by (Prentice Hall India).
8. Verdeyen J. T. (1993) *Laser Electronics* by (Prentice Hall of India Private Limited).
9. Wilson J. and Hawkes J.F.B. (1987) *Lasers: Principal and Applications* (Prentice Hall International (UK) Limited).
10. Laud B. B. (2011) *Non linear Optics* (New Age International Private Limited)

Suggested web-resources:

https://nptel.ac.in/courses/104104085/

https://ocw.mit.edu/resources/res-6-005-understanding-lasers-and-fiberoptics-spring-2008/index.htm

PHY 530 Solid State Physics

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

On successful completion of the course, Student will be able to:

- Understand how the large-scale properties of solid materials result from their atomic-scale properties.
- Seek various applications of solid state physics in technology of semiconductors and semiconductors based devices.

Section A

Lattice dynamics and optical properties of solids:

Interatomic forces and lattice dynamics of ionic & covalent crystals, and metals. Analysis of strain, elastic compliance and stiffness constants, elastic energy density, elastic stiffness constants of cubic crystals and elastic waves in cubic crystals.

Vibration of crystals with monatomic basis, two atoms per primitive basis, quantization of elastic waves, phonon momentum, inelastic scattering by phonons, phonon heat capacity, Plank distribution, density of states in one and three dimensions, Thermal properties of solids: Classical model, Einstein model, Debye model and, Debye T^3 law, thermal conductivity, phonon-phonon interaction-umklapp process, thermal expansion.

Section B

Band theory and semiconductors:

Nearly free electron model, origin and magnitude of energy gap, Bloch function, Kronig-Penney model, wave equation of electron in periodic potential.

Number of orbitals in a band, band gap of semiconductors, equation of motion, intrinsic carrier concentration, impurity conductivity, Tight bonding method for energy gap.

Superconductivity:

Meissner effect, type I & type II superconductors, heat capacity, microwave and infrared properties, isotope effect,

London equation, coherence length, Cooper pairs, BCS theory (no derivation), field quantization in a superconducting ring, duration of persistent current, high temperature superconductors

Section C

Diamagnetism and Paramagnetism:

Langevin Diamagnetism equation, quantum theory of diamagnetism of mononuclear systems, Paramagnetism, quantum theory of paramagnetism. Cooling by isotropic demagnetization, paramagnetic susceptibility of conduction electrons.

Ferromagnetism and Antiferromagnetism:

Ferromagnetic order, magnons, Neutron magnetic scattering, ferromagnetic order, Antiferromagnetic order, Ferromagnetic domains,

Nuclear magnetic resonance, Nuclear quadrupole resonance, ferromagnetic resonance, Electron paramagnetic resonance

Recommended Books:

1. Kittel C. (1995) *Introduction to Solid state Physics* (John Wiley).
2. Dekker A. J. (1965) *Solid State Physics* (Macmilam, London).
3. Pillai S. O. (2005) *Solid state physics* (New Age International Publishers).
4. Singhal R. L. (2001) *Solid State Physics* (Kedar Nath Ram Nath Publishers).

Suggested web-resources:

https://nptel.ac.in/courses/115104109/

https://nptel.ac.in/courses/115105099/

PHY 537L Physics Lab - II

	L	T	P	C
Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**8**	**4**

Learning Outcomes:

On successful completion of the course, Student will be able to:

- Assess the validity of physical theories through the design and execution of an experiment, the analysis of uncertainties associated with the measurement of data and the interpretation of the data to draw valid scientific conclusions (lab skills).
- Connect a digital oscilloscope to a computer and record a signal with an appropriate sampling rate;
- Generate and interpret the power spectrum of the recorded data,

- Use the tools, methodologies, language and conventions of physics to test and communicate ideas and explanations

List of Experiments:

(The students are required to perform at least twenty four experiments in all)

Part- A

1. To study the Electro–optic effect and AC modulation.
2. To study the thermal expansion of quartz crystal using Newton's ring method.
3. To study acoustic –optic effect.
4. To study the Brewster angle and refractive index of a given material.
5. To determine the attenuation and bending losses of an optical fiber.
6. To study Gaussian distribution of intensity of laser beam.
7. To study the spatial and temporal coherence of laser.
8. To determine the particle size by diode laser.
9. To study the nature of polarization.
10. To determine the speed of light using laser.
11. To setup a fiber optics analog and digital link.
12. To study the losses in optical fiber.
13. To study numerical aperture of optical fiber.
14. To study the characteristics of a fiber optics LED and photo detector.
15. To study time division multiplexing.
16. To study framing in TDM.
17. To study marker in TDM.
18. To study Manchester coding and decoding.
19. To study PCM voice coding and frequency response of CODEC.

Part- B

1. To study the Hall Effect in metals and determination of allied parameters.
2. To study the Hall Effect in semiconductor and determination of allied parameters.
3. To study the nuclear magnetic resonance(NMR) spectroscopy and determine Landes g factor

4. To determine the dielectric constant of the given sample at different temperature and then Transition temperature (Curie temperature) by plotting graph.
5. To determine the band gap of given germanium with the help of four probe method.
6. To determine the magnetic susceptibility of paramagnetic solution($FeCl_3$) by Quinck's tube method.
7. To determine the magnetic susceptibility of solid sample by Gouy's Method Apparatus.
8. To determine the ultrasonic velocity and then obtain the compressibility of the given liquid.
9. To determine the ultrasonic velocity and then obtain the compressibility of the given solid sample at deferent temperature.
10. To study the variation of rigidity of given specimen as a function of the temperature.
11. To study the dynamics of lattice using electrical analogue.
12. To determine the hysteresis loss in transformers.

PHY 527S Seminar

	L	T	P	C
Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**2**	**1**

Learning Outcomes:

- learn through self study
- present the work of their dissertation

Fourth Semester

ELE 307 Microwave Electronics

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

On successful completion of the course, Student will be able to:

- understand fundamentals of microwaves
- have the knowledge of transmission lines and their properties
- have the knowledge of microwave tube devices

Section A

Transmission Lines: Introduction to Microwaves & its applications. General equation, input independence characteristic, Reflection & transmission coefficient, standing wave ratio, resonant and anti resonant line impedance matching, smith chart & its applications, coaxial, twin, strip & microstrip lines & baluns.

Section B

Wave Guides: Wave propagation in rectangular & circular wave guides, wave guide modes, Q of wave guides, wave guide coupling. Microwave Passive Components: s-parameter representation and analysis of microwave component such as tees, two hole direction coupler attenuators, phase shifter, Rectangular cavity resonator, circulator & isolator.

Section C

Microwave Tube Devices: Conventional Vacuum tubes at microwave, Slow-wave devices, O-type device- Klystron two cavity, Reflex- Klystron, M-type device–Magnetron, Introduction to TWT (Travelling Wave Tubes), Microwave Semiconductor Devices IMPATT, TRAPATT, Gun Diode,

Introduction of fast wave device: Gyrotrons (Concepts only)

Text/Reference Books:

1. Sisodia R. (1987) *Microwave Circuits & passive devices*, (Wiley-eastern).
2. Liao S.Y., (2002) *Microwave devices & circuits,* III Ed., (Prentice Hall).
3. Collin, (1992) *Foundation of microwave engineering*, (Mc Graw Hill), II Ed.

4. Sisodia R. (1987) *Basic MW techniques & lab manual*, (Wiley-Eastern).
5. Reach H. J. (1999) *Microwave Principles,* (CBS Publishers & Distributors).
6. Rizzi P. A. (1998) *Microwave Engineering, Passive Circuits*, (Prentice Hall).

Suggested web-resources:

https://lecturenotes.in/subject/83/microwave-engineering-me

https://lecturenotes.in/notes/85-notes-for-microwave-engineering-me-by-lopamudra-mishra

PHY 517 Nuclear Physics - II

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

On successful completion of the course, Student will be able to:

- Understand the concept of nuclear physics.
- Understand the structure of matter at the atomic level.
- Understand the interactions of the atom molecules and the building blocks.
- Understand the nuclear power generation and nuclear weapons technology.

Section A

Nuclear models: Degenerate gas model, α-particle model, Liquid drop model, semiempirical mass formula, mass parabolas, Shell model, single particle and collective motions in nuclei, assumptions and justification of the shell model, average shell potential, spin orbit coupling, single particle wave function and energy level sequence, magic numbers, shell prediction for ground state parity, angular momentum ,magnetic dipole moment, electric quadrupole moment and their comparison with experimental data.

Section B

Radioactive Decay: Radioactive Decay Law, Radioactive Dating.

Alpha Decay: Scattering of α-particles, α-decay and barrier penetration, Gamow's theory of α-decay.

Beta Decay: Fermi theory of β-decay (parity conserved selection rules-Fermi and Gamow-Teller), experimental verification of parity violation, the V-A interaction and experimental evidence.

Gamma Decay: Electric and magnetic multipole moments and gamma decay probabilities in nuclear systems (no derivations), reduced transition probabilities, selection rules, internal conversion and zero-zero transitions.

Section C

Nuclear Reactions: Conservation Laws of nuclear reactions, Classification of Nuclear Reactions, partial wave analysis of reaction cross section, compound nucleus formation and break up, Ghoshal experiment, resonance scattering, Briet-Wigner formula for s-wave (l=0), theory of stripping and pickup reactions, nuclear structure studies deuteron stripping (d,p) reactions, determination of spin and angular momentum for the direct reactions.

Elementary particles: Classification of elementary particles, Fundamental interactions, conservation laws, Properties of elementary particles, Symmetry schemes of elementary particles, Quark model.

Recommended Books:

1. Kaplan I. (1955) *Nuclear Physics* (Addison Wesley Pub. Co.)
2. Roy R. R., Nigam B. P. (1997) *Nuclear Physics Theory and Experiment* (New Age Internation Pub.)
3. Evans R.D. (1965) *Atomic Nucleus* (McGraw Hill)
4. Ghoshal S. N. (2006) *Nuclear Physics* (S. Chand, New Delhi).
5. Singru R. M. (1975*) Introduction to Experimental Nuclear Physics* (Wiley Eastern pvt. Ltd.)
6. Patel S. B. (1992) *Nuclear Physics: an Introduction* (Wiley Eastern Ltd.).

Suggested web-resources:

https://nptel.ac.in/courses/115104043/

https://nptel.ac.in/courses/115103101/

PHY 529 Solid State Electronics Devices

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

After completion of this course the students will be able to –

- Understand the mechanism of semiconductor devices
- Understand the applications of semiconductor devices in routine life
- Make advancement in these devices

Section A

Energy Bands, direct and indirect semiconductors, Effective Mass, Intrinsic and Extrinsic Semiconductors, Occupation Probability and Carrier Concentration, Temperature Dependence of Carrier Concentration, Fermi Levels and Quasi Fermi levels, mobility and conductivity, Hall Effect, four probe method of resistivity measurement.

Generation and Recombination of Charges, diffusion, Continuity equation, Injected minority charge carriers, the potential variation within a graded semiconductor, Schottkg Junction and Olimic Contact.

PN junction diode, Zener diode, Zener and Avalanche breakdown, Tunnel diode, Semiconductor Photo diode and Light-emitting diode.

Section B

Bipolar junction transistor:- Types, Current components, CB, CC, CE configuration, Ebers-Moll model of transistors.

Concept of load line and Operating point, Thermal stability of transistor, Fixed-Bias, Emitter-Bias, Voltage divider Bias, Collector feedback Configuration.

Transistor Hybrid model, analysis of a transistor amplifier circuit using h-parameters, Simplified hybrid model for CE, CB and CC configuration, The Common-Emitter amplifier with an emitter resistance, Emitter follower, Darlington emitter follower,

Junction field effect transistor and Depletion and Enhancement type MOSFET; V-I characteristic, operation methods, FET Biasing: Fixed, Self and Voltage-divider Bias. low and high frequency model (just reference).

Section C

Operational amplifiers and its applications, inverting and non-inverting amplifiers, adder, integrator, differentiator, wave-form generator, comparator, Schmitt trigger.

Four layer diode (P-N-P-N), SCR, Principle of operation, transistor analogy, methods of turning On and Turning Off (just reference), Gate characteristic, DIAC, TRIAC, light activated thyristor, Applications of SCR in the following areas: Over voltage protection, Zero voltage switch, Logic and Digital Circuits, Pulse circuits.

Recommended Books:

1. Millaman J. and Halkias C. (1972) *Integrated Electronics* (McGraw Hill, New York),
2. Malvino L. (1999) *Electronic Devices and circuits*
3. Sterectman B. G. (1995) *Solid State Electronic Devices and Integrated Circuits* (Prentice Hall Inc.).
4. Sze S.M. (1999) *Physics of Semiconductors Devices* by (John Wiley & Sons).

Suggested web-resources:

https://nptel.ac.in/courses/115102014/

https://nptel.ac.in/courses/113106062/

https://nptel.ac.in/courses/117106091/

PHY 519L Physics Lab - III

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**8**	**4**

Learning Outcomes:

On successful completion of the course, Student will be able to:

- Assess the validity of physical theories through the design and execution of an experiment, the analysis of uncertainties associated with the measurement of data and the interpretation of the data to draw valid scientific conclusions (lab skills).
- Connect a digital oscilloscope to a computer and record a signal with an appropriate sampling rate;
- Generate and interpret the power spectrum of the recorded data,
- Use the tools, methodologies, language and conventions of physics to test and communicate ideas and explanations

List of Experiments:

(The students are required to perform at least sixteen experiments in all)

Part-A

1 Determine the operating frequency of Reflex klystron.

2 Draw the V-I characteristics of Reflex klystron.

3 Draw the characteristics of attenuator.

4 To verify the wave guide law.

5 To study the directivity and coupling coefficient of directional coupler.

6 To study the properties of magic Tee and also determine isolation and coupling coefficient.

7 To determine the VSWR of (i)short circuit (ii)open circuit (iii)matched load (iv)unmatched load.

8 To study the properties of E plane and H plane Tees and also determine isolation and coupling coefficient

9 To determine the operating voltage and dead time of GM counter using Cs137radioisotops.

10 To determine the absorption coefficient of Aluminum and lead for Beta particles using Cs137radioisotops and GM counter.

11 To study the statistical nature of radioactive decay using GM counter and Cs137radioisotops.

12 To study spectrum of beta particles using gamma ray spectroscopy.

13 To calibrate a scintillation counter and determine energy of gamma rays from an unknown source.

14 To study the alpha particle using spark chamber.

15 To study the Bremsstrahlung effect using Scintillation spectroscopy.

16 To study Crompton scattering of gamma-rays and verify the energy shift formula.

17 To determine the end point of beta particle using beta ray spectrometer.

18 To determine the half life a radio isotope using GM counter.

Part-B

1 To study the V-I characteristics of FET using discrete components on bread board.

2 To study the V-I characteristics of UJT.

3 To study the output and transfer characteristics of FET.

4 To study the input and output characteristics of BJT.

5 To study the V-I characteristics of DIAC.

6 To study the V-I characteristics of TRIAC.

7 To study the V-I characteristics of SCR.
8 To study the characteristics of optocoupler and draw its frequency response.
9 To study the V-I characteristics of Photodiode.
10 To study the V-I characteristics of p-n junction diode using discrete components on bread board.
11 To study the V-I characteristics of pnp or npn transistor using discrete components on bread board.
12 To study the amplitude modulation and demodulation.
13 To study the frequency modulation and demodulation.
14 To study the balance modulation and demodulation.
15 To study the pulse amplitude modulation and demodulation.
16 To study the pulse with modulation and demodulation.
17 To study the pulse position modulation and demodulation.
18 To study the pulse code modulation and demodulation.
19 To study the digital modulation and demodulation technique ASK, FSK and PSK.

PHY 525P Project

	L	T	P	C
Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**8**	**4**

Learning Outcomes:

- Learn through self study
- Learning of writing the dissertation
- Present the work of their dissertation

Discipline Elective

PHY 534 Condensed Matter Physics - I

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

On successful completion of the course, Student will be able to:

- Explain the significance and value of condensed matter physics, both scientifically and in the wider community
- Critically analyse and evaluate experimental strategies, and decide which is most appropriate for answering specific questions
- Research and communicate scientific knowledge in the context of a topic related to condensed matter physics, in either a technical or non-specialist format

Section A

Structure of solids: Crystalline and amorphous solid, Bravais lattice, basis and crystal structure, primitive unit cell, Wigner-Seitz cell, Symmetry operations and classification of 2- and 3- dimensional Bravais lattice, Concept of point group and space group; Common crystal structures: FCC, BCC, NaCl, Diamond and Zinc blend, Wurtzite structure, tetrahedral and octahedral interstitial sites, spinel structure; Three dimensional crystal systems (Miller indices, direction and planes in crystal, inter-planar spacing).

X-ray diffraction and reciprocal lattice X-ray diffraction by crystal, Laue theory, Bragg law, Reciprocal lattice and Brillouin zone, Ewald construction, Static structure factor and its relation with pair correlation function, Atomic and geometric structure factor, Systematic absences, Neutron and electron diffraction (brief discussion).

Section B

Dielectric and magnetic properties of solids: Electronic, ionic, and orientational polarization; static dielectric constant of gases and solids; Complex dielectric constant and dielectric losses, relaxation time, Debye equation; Cases of distribution of relaxation time, Cole-cole distribution parameters, Dielectric modulus Ferroelectricity, Displacive phase transition, Landau theory of phase transition.

Weiss theory of ferromagnetism, Heisenberg model and molecular field theory; Spin waves and magnons, Ferri and antiferro-magnetic order, Domain and Bloch wall energy.

Section C

Aperiodic and semiperiodic systems: Structure and symmetries of liquids, liquid crystals and amorphous solids. Aperiodic solids and quasicrystals, Fibonacci sequence and Penrose lattices and their extension to quasicrystals.

Imperfections in solids: Frankel and Schottky defects, defects by non-stoichiometry; electrical conductivity of ionic crystals; classifications of dislocations; role of dislocations in plastic deformation and crystal growth

Recommended Books:

1. Hansen and McDonald (2013) *Theory of simple liquids* (Academic Press; 4 edition).
2. Kittel C., (2005) *Solid Stae Physics*, Wiley Student ed.
3. Pines D. and Nozier P. (1999) *The Theory of Quantum Liquids* (Avalon Publishing).
4. Tilley J. and Tilley D. R. (1990) *Superfluidity and Superconductivity* (Taylor and Francis Group).
5. March, Tosi and Street (1985) *Amorphous Solids and Liquid State* (Plenum).
6. Hari Singh Nalwa (1999) *Handbook of Nanostructured Materials & Nanotechnology* (Academic Press).

Suggested web-resources:

https://nptel.ac.in/courses/122102008/26

https://nptel.ac.in/courses/113102080/36

https://ocw.mit.edu/courses/materials-science-and-engineering/3-071-amorphous-materials-fall-2015/index.htm

PHY 507 Fiber Optics Communication

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

On successful completion of the course, Student will be able to:

- Understand the use of fiber optics in communication.
- Understand the capacity and internet services, with fiber.
- Understand the advances in technology.

Section A

Light propagation- total internal reflection, Acceptance angle and Numerical aperture. Fiber materials and Fabrication, Mechanical properties of Fiber, Fiber cables, comparison of Fiber cables with conventional metallic cables.

Optical Fibers- step index, single and multimode, graded index. Fiber losses and dispersions.

Section B

Light Emitting diodes- spontaneous emission – surface emitting LED, edge emitters, semiconductor diode LASER- stimulated emission, Double hetero structure LASER, drivers for LED and LASER, Photo conductive – photo voltaic effect, Solar cells- p-n homojunction, heterojunction and amorphous Solar cells.

Fiber end preparations, Fiber splicing, Fiber connector, connection losses, Fiber couplers.

Section C

Photo detectors- characteristics of photo detectors- photoconductor, p-n photodiode, PIN photodiode Schottky barrier photodiode, Avalanche photodiode, Phototransistor.

Integrated optics, Fiber Optic communication system- applications of Fiber Optics- long haul communications, local area network, under sea communication, sensors, medical applications.

Recommended Books:

1. John M. S. (2004) Optical Fiber communication (Prentice Hall of India).
2. Gowar J. (1995) *Optical Fiber communication* (Prentice Hall of India).
3. Bhattacharya P. (1994) *Semiconductor Optoelectronics Devices* (Prentice Hall of India).
4. Keiser G. (2007) *Optical Fiber communication* (McGraw Hill).

5. Wilson J. and Hawkes J.F.B. (1989) *Optoelectronics: An Introduction* (Prentice Hall International (UK) Limited).
6. Gupta S.C. (2005) *Optoelectronic Devices and Systems* (Prentice Hall India)
7. Polais J. C. (2008) *Fiber Optics Communication* (Pearson Education).

Suggested web-resources:

https://nptel.ac.in/courses/117104127/

https://nptel.ac.in/courses/117101002/

PHY 509 High Energy Physics-I

	L	T	P	C
Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

On successful completion of the course, Student will be able to:

- have knowledge of fundamental particles.
- have knowledge about fundamental interactions and the range and strength of these interactions with the concept of particle antiparticle or matter antimatter.

Section A

Historical Development, classification of particles-Fermions and Bosons, particles and antiparticles, Basic Fermion constituents, quarks and leptons, Hadrons-composites of Quarks and antiquarks, Interactions and Fields in Particle Physics, Electromagnetic, Gravitational, weak and stong interactions, Hardron-Hadron Interactions, Conservation Rulers in Fundamental Interactions.

Invariance in Quantum mechanics, Translations and rotations, Parity, Spin and Parity of the Pion. Parity of Particles and Antiparticles, Tests of parity conservation, charge conservation, Charge conjugation Invariance, Eigen states of charge conjugapon Operator, Positronium decay, Experimental text of C invaiance, time reveral invanance, C-P viotation and CPT Theorem.

Section B

Cross section and decay rates, Isospin, Isospin in the Two Nucleon system, Isospin in the Pion-Nucleon System, Strangeness and Isospin.

Dalitz Plots : Three- Body Phase space, $K \rightarrow 3\pi$ decay, Dalitz Plots involving three Dissimilar Particles, total and elastic cross sections, particle production at high energy, Quark Antiquark combinations: The Pseudo-scalar Mesons, The Vector Mesons, Leptonic decays of Vector mesons.

Section C

Classification of Weak Interactions, Fermi theory of Nuclear decay, Interaction of Free Neutrinos; Inverse β–decay, Helicity of the neutrino, the V-A interaction, Parity Violation in Λ-decay, Parity Nonconservation in β decay, Pion and Muon decays, π → μ Decay and π → e Branching ratios, Weak decays of Strange Particles, cabibbo Theory, K_0 decay, Strangeness Oscillations, the K_0 Regeneration Phenomenon, CP violation in K_0 decay.

Recommended Books

Perkins D. H. (2000) Introduction to High Energy Physics (Addison Wesley).

Suggested web-resources:

https://nptel.ac.in/courses/115103101/

PHY 514 Nonlinear Physics – I

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

On successful completion of the course, Student will be able to:

- Have an advanced knowledge of nonlinear dynamics.
- Understand the connection between nonlinear systems and their physical realization.
- Understand the qualitative features of nonlinear dynamical systems.

Section A

Dynamical systems: linear and nonlinear dynamical systems, working definition of nonlinearity and effects of nonlinearity.

Linear oscillators and predictability: free oscillations, damped oscillations, damped and force oscillations.

Nonlinear oscillators: free oscillations, damped oscillations, forced oscillations, primary resonances and jump phenomenon, secondary resonances - subharmonic and superharmonic, nonlinear oscillations and bifurcations.

Qualitative features of dynamical systems: Autonomous and non-autonomous systems, equilibrium points, phase space and phase space trajectories, stability of equilibrium points, attractors and repellors, Criterion for stability of equilibrium points and classification of equilibrium points, periodic attractors, quasi periodic attractor, chaotic attractor, concept of dissipative and conservative dynamical systems.

Section B

Simple bifurcations: Saddle node bifurcation, pitchfork bifurcation, transcritical bifurcation, Hopf bifurcation.

Chaos in discrete dynamical systems: equlibrium points of logistic map and their stability, periodic solutions, chaotic solution and sensitivity on initial condition, bifurcation diagram, construction of Coweb diagram, strange attractor and self similarity in Henon-map, period doubling route to chaos in Henon map.

Route to chaos: Period-doubling route to chaos, quasiperiodic route to chaos, intermittence route to chaos, type-I intermittence and standard bifurcations in maps.

Chaos in dissipative nonlinear oscillators: Bifurcation and chaos in Duffing oscillator, intermittent transition, quasiperiodic route and strange non-chaotic attractors, period doubling and bifurcation in Lorenz equations, introduction to other chaotic oscillators-driven Van der Pol oscillator, damped and driven pendulum, Morse oscillator and Rossler oscillator, necessary conditions for the occurance of chaos in discrete and continuous dynamical systems.

Section C

Chaos in nonlinear electronic circuits: linear and nonlinear electronic circuit elements, linear circuit-resonant RLC circuit, nonlinear circuits-Chua's diode and bifurcation and chaos in circuit containing Chua's diode, chaos in simplest dissipative circuit-MLC circuit and its stability analysis, analytical and numerical studies, other useful nonlinear circuits: RL diode circuit, Hunt's nonlinear circuit, p-n junction diode oscillator and Colpitt's oscillator

Characterization of periodic and chaotic motions: Lyapunov exponents, computation of Lyapunov exponents for maps and continuous dynamical systems, power spectrum, autocorrelation and dimension of attractor and criterion for chaotic motion.

Advances in chaotic dynamics: time-series analysis, chaotic scattering, controlling of chaos, synchronization of chaos (only brief introductions).

Recommended Books:

1. Lakshmanan M. and Rajasekhar S. (2003) *Nonlinear Dynamics: Integrability, chaos and patterns* (Springer Verlag).

2. Hillborn R. C. (2000) *Chaos and nonlinear Dynamics* (Oxford University Press).
3. Guckenheimer J. *and Holmes P. (1990) Nonlinear oscillations, dynamical systems and bifurcation of vector fields* (Springer Verlag, New Yorke).
4. Moon F. C. (1992) *Chaotic and fractal dynamics* (John Wiley and Sons).
5. Alligwood K., Sauer T. and Yorke J. A. (1997) *Chaos-An introduction to dynamical systems* (Springer Verlag, New York).
6. Ott E. (1993) *Chaos in dynamical systems* (Cambridge University Press).

Suggested web-resources:

https://nptel.ac.in/courses/108106085/

PHY 521 Physics of Nano-structures and Nanotechnology-I

Max. Marks : 100	**L T P C**
(CA: 40 + ESA: 60)	**4 0 0 4**

Learning Outcomes:

On successful completion of the course, Student will be able to:

- Understand the fundamental of nano-science & technology.
- Able to apply the knowledge in material science, molecular electronics, synthetic biomolecular motors, DNA-based self-assembly, and manipulation of individual atoms via a scanning tunneling microscope

Section A

Introduction to Quantum Mechanics: Matterwaves, Schrodinger equation, idea of quantum well structure, quantum dots, quantum wires, density of states for 0-d solid, 1-d quantum wire, 2-d and 3-d potential box.

Charge and Current densities, Introduction to Density Functional Theory, Optical measurements of Band gap.

Structure and bonding: arrangement of atoms, two and three dimensional crystals, symmetry elements in crystals, plane in crystals, reciprocal lattice, quasi crystals.

Surface crystallography, Surface symmetry, Surface energy, surface reconfiguration, surface reconstruction and relaxation.

Section B

Synthesis of Nanomaterials: Physical methods- high-energy ball milling, melt mixing, Method based on evaporation, Sputter deposition, chemical vapor deposition, molecular beam epitaxy.

Synthesis of Nanomaterials: Chemical methods- Colloids and colloids in solution, synthesis of metal and semiconductor nanoparticles by colloidal route, Langmuir–Blodgett method, microemulsions, sol-gel method.

Nano Lithography- lithography using photon, lithography using particle beam, Scanning probe lithography, Soft lithography.

Section C

Analysis techniques: Microscopes: optical, confocal, electron microscopes (SEM & TEM), scanning probe microscopes (SPM)-scanning tunneling microscope, scanning near-field optical microscope, atomic force microscope.

Diffraction techniques: X-ray diffraction-Bragg's law of diffraction, diffraction from different types of samples, diffraction from nanoparticles.

Spectroscopies: Optical absorption spectrometer, infrared spectrometer (dispersive, Fourier transform), photoluminescence spectrometer, X-ray photoelectron spectroscopy, and Auger electron spectroscopy.

Recommended Books:

1. Pillai S.O. (2007) *Solid State Physics* (New Age International).
2. Kulkarni S.K. (2007) *Nano technology; principle and practices* (Capital Publishing Company)
3. Jain K. P. (1997) *Physics of semiconductor nanostructures* (Narosa Publishers).
4. Garundmann D.M. and Ledentsov N.N. (1998) *Quantum dot heterostructures* (John- Wiley).
5. Poole C.P., Owens F.J. (2003) *Introduction to Nanotechnology* (Wiley-Interscience).
6. Wilson M., Kannangara K., Smith G., Simmons M. and Raguse B. (2002) *Nanotechnology: Basic Science & Emerging Technologies* (Chapman & Hall/CRC Press).

Suggested web-resources:

https://nptel.ac.in/courses/118102003/

https://nptel.ac.in/courses/118106019/

https://nptel.ac.in/courses/118104008/

PHY 523 Plasma Physics-I

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

On successful completion of the course, Student will be able to:

- Understand the fourth state of matter
- Have technological innovations stemming from plasma science

Section A

Basic properties and occurrence- Definition of plasma, Criteria for plasma behaviour, Plasma oscillation, Quasineutrality and Debye shielding, The plasma parameter, natural occurrence of plasmas, Astrophysical plasmas, Plasma in Magnetosphere and ionosphere, Plasma production and diagnostics, Thermal ionization. Saha equation, Brief discussion of methods of laboratory, plasma production, Steady state flow discharge, microwave breakdown and induction discharge, Double Plasma Machine, Elementary ideas about plasma diagnostics, electrostatic and magnetic probes.

Section B

Charged particle motion and drifts, Guiding center motion of a charges particle, Motion in (i) uniform electric and magnetic fields (i) gravitational and magnetic fields, Motion in non-uniform magnetic field (i) grade B perpendicular to B, grad B drift and curvature drift 01) grade B parallel to B and principle of magnetic mirror, Motion in non-uniform electric field for small larmour radius, Time varying electric field and polarization drift, Time varying magnetic leld adiabatic invariance of magentic moment.

Section C

Plasma fluid equations fluid equations : Convective derivative, Two fluid and single fluid equations, Fluid drifts perpendicular to B, diamagnetic dnift.

Diffusion and resistivity : Collision and dffi'sion parameters, Decay of a plasma by diffusion, ambipolar diffusion, Diffusion across a magnetic,field, Collision in fully ionized plasma, Plasma resistivity, Diffusion in fully ionized plasmas, Solution'of Diffiision equation.

Equilibrium and stability : Hydromagnetic equilibrium, Concept of magnetic pressure, Equilibrium of a cylindrical pinch, The Bennet pinch, Diffusion of magnetic field into a plasma, Classification of instabilities, Two stream instability, The gravitational instability, Resistive drift waves.

Recommended Books:

1. Chen F.F. (1974) *An Introduction to Plasma Physics* (Plenum Press).
2. R.C. Davidson (1972) *Methods in Non-linear Plasma theory* (Academic Press),.
3. Kunkel W.B. (1966) *Plasma Physics in Theory and Application* (McGraw Hill).
4. Bittencoms J. A. (1986) *Fundamentals of Plasma Physics* (Pergamons Press).

Suggested web-resources:

https://nptel.ac.in/courses/115102020/

PHY 526 Science and Technology of Solar Hydrogen and other Renewable Energies

	L	T	P	C
Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

On successful completion of the course, Student will be able to:

- Understand the role of solar energy.
- Understand about energy, production and storage.

Section A

Solar Energy: Fundamentals of photovoltaic Energy Conversion Physics and Material Properties Basic to Photovoltaic Energy Conversion : Optical properties o Solids. Direct and indirect transition semiconductors, interrelationship between absorption coefficients and band gap recombination of carriers.

Types of Solar Cells: p n junction solar cell, Transport Equation, Current Density, Ipen circuit voltage and short circuit current, Brief descriptions of single crystal silicon and amorphous silicon solar cells, elementary ideas of advanced solar cells e.g. Tandem Solar Cells. solid Liquid Junction Solar Cells, Nature of Semiconductor, Electrolyte Junction, Pricniples o Photoelectrochemcial solar Cells.

Section B

Hydrogen Energy : Relevance in depletion of fossil fuels and enviromnental considerations.

Hydrogen Production : Solar Hydrogen through Photoelectrolysis and Photocatalytic process. Physics and material characteristics for production of Solar Hydrogen.

Storage of Hydrogen : Brief discussion of various storage processes, special features of solid state hydrogen storage materials, structuraland electronic characteristics of storage materials. New Storage Modes.

Section C

Safety and Utilisation of Hydrogen : Various factors relevant to safety, use of Hydrogen as Fuel, Use in Vehicular transport, Hydrogen for Electricity Generation, Fuel Cells, Elementary concepts of other Hydrogen Based devices such as Air Conditioners and Hydride Batteries.

Other Renewabel Clean Energies : Elements of Solar Thermal Energy, Wind Energy and Ocean Thermal Energy Conversion.

Recommended Books:

1. Fonash S. J. (2012) *Solar Cell Devices - Physics.* (Academic Press)
2. Fahrenbruch & Bube (1983) *Fundamental of Solar Cells Photovoltatic Solar Energy* (Academic Press).
3. Chandra S. (1985) *Photoelectrochemical Solar Cells*. (Gordon and Breach Science Publishers)
4. Winter C. J. & Nitch J (1988) *Hydrogen as an Energy Carrier Technologies System Economy* (Springer-Verlag).

Suggested web-resources:

https://nptel.ac.in/courses/108105058/40

PHY 532 Biophysics-I

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

On successful completion of the course, Student will be able to:

- Understand the concepts of physical principles in the biomolecular systems.
- Know Properties and
- conformations of biomolecules.
- Understand the interaction between physics and biology.

Section A

Introduction: Brief introduction to all aspects of Biology, cellular automata, Conway's Game of life. Cell structure and function: Cell theory, cell membrane and transport, membranous organelles, Nonmembranous organelles, Nuclear components and major cell types, viruses. Molecules in the cell: Carbohydrates, lipids, proteins and nucleic acids, their structure and function.

Code of life: Central dogma, DNA replication, transcription and translation.

Energy in life forms: Cellular Respiration, Glycolysis, Krebs cycle, Electron transport chain, ATP calculation, Photosynthesis, C4 pathway.

Section B

Intermolecular interactions: Covalent interactions, disulphide bonds, van der Waals interactions, bond angles and torsions. Role of hydrogen bonding and hydrophobic interaction in biomolecular structures. Examples of α-helices and β-sheets in proteins, Watson-Crick pairs in DNA, stacking interactions in DNA and RNA. Protein Conformation: Conformational properties of polypeptides, Ramachandran plot, Helical parameters and conformation, organization as secondary and supersecondary structures in proteins, domains and motifs. Protein folding in vivo and in vitro of globular proteins, basic idea.

Section C

Molecular Mechanics: Force field equation, Lennard Jones Potential, Potential energy surface, Z-matrix, Molecular modeling, Energy minimization techniques, Exhaustive search method, steepest descent and conjugate gradient methods, Molecular dynamics simulation, Verlet algorithm and simulated annealing protocol. Experimental techniques used to determine biomolecular structure: Principles and application of UV-visible, circular dichroism and fluorescence spectroscopy. Case studies on Helix to coil transitions, melting curves in proteins and DNA structures.

X-ray crystallography of biomolecules : Obtaining single crystals of biomolecules, Single crystal data collection, Determination of point group, spacegroup from symmetry of diffraction patterns, deducing cell parameters, interpretation of intensity data, Calculation of electron density, Solving the phase problem, Structure validation.

Recommended Books:

1. Tuszynski, J. A., & Kurzynski, M. (2003). *Introduction to molecular biophysics*. CRC press.

2. Schlick, T. (2010). *Molecular modeling and simulation: an interdisciplinary guide: an interdisciplinary guide* (Vol. 21). Springer Science & Business Media.
3. Voet, D., Voet, J. G., & Pratt, C. W. (2013). *Fundamentals of biochemistry: life at the molecular level* (No. 577.1 VOE). Hoboken: Wiley.

Reference Book :

1. Cantor, C. R., & Schimmel, P. R. (1980). *Biophysical chemistry: Part III: the behavior of biological macromolecules*. Macmillan.
2. Van Holde, K. E. J. W. *Principles of physical biochemistry*/Kensal E. Van Holde, W. Curtis Johnson, P. Shing Ho.
3. Jensen, J. H. (2010). *Molecular modeling basics*. CRC Press.
5. Nelson, P. (2004). *Biological physics*. New York: WH Freeman.

Suggested web-resources:

1. https://nptel.ac.in/syllabus/102101006/
2. https://www.edx.org/course/quantum-mechanics-molecular-structures-utokyoxutokyo003x-1

PHY 503 Analog and Digital Communication

	L	T	P	C
Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

On successful completion of the course, Student will be able to:

- Understanding the communication using electronic media.
- Understanding the usage of electronic devices in telecommunications.

Section A

Spectrum Analysis: Fourier series, Sampling, functions. Normalized power, Fourier transform. Parsevals theorem, Convolution, Signal transmission through linear time invariant systems, correlation and power spectrum, Random signals and noise, Basic information theory.

Analog Modulation Systems: Amplitude modulation, depth of modulation, spectrum of an A.M. signal, square law modulator, Balanced modulator, D.S.B.S.C. modulation, S.S.B. modulation, vestigial sideband modulation.

Section B

Frequency modulation, phase modulation, relationship between phase and frequency modulation. Spectrum of F.M. Signal, generation and detection of F.M. signal. Comparision of AM & FM. Digital modulation systems: Sampling theorem, PAM, PWM,PPM, quantization od signals, quantization error, Pulse-code modulation, companding, DPCM, Delta modulation, adaptive delta modulation, ASK, FSK, PSK, DPSK.

Section C

Satellite Communication - History of orbital satellites, Geostationary Satellites, Orbital patterns, Look Angles, Orbital spacing and Frequency allocation, Radiation Patterns: Footprint, Satellite System link models, Satellite system parameters, FDM/FM satellite systems. Introduction to Communication systems: Radio, T.V., Telegraph & Telex, EPABX, FAX, Cellulor telephones, Telemetry.

Recommended Books:

1. Taub H and Schilling D L (1999) *Principles of Communication Systems* (McGraw Hill)
2. Davis B and Kennedy G (1999) *Electronics Communication Systems* (Mc-Graw Hill).
3. Haykins S. (2001) *An Introduction to Analog & Digital Communications* (John Wiley & Sons).
4. R.E. Zimer & W.H. Tranter (1995) *Principles of Communications-Systems, Modulation & Noise* (Jaico Publishing House).
5. Roddy D, Coolen J (2000) *Electronics Communications* (PHI), III Edition.
6. Schaum's outline series *Analog and Digital Communications*, (Mc Graw Hill)
7. Schoenbeck R. J. (1995) *Electronics Communications* (Universal Book Stall)

Suggested web-resources:

https://nptel.ac.in/courses/117105143/

PHY 535 Condensed Matter Physics - II

	L	T	P	C
Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

On successful completion of the course, Student will be able to:

- Explain the significance and value of condensed matter physics, both scientifically and in the wider community.
- Critically analyse and evaluate experimental strategies, and decide which is most appropriate for answering specific questions in research and communicate scientific knowledge in the context of a topic related to condensed matter physics, in either a technical or non-specialist format.

Section A

Interacting electron gas: Hartree and Hartree-Fock methods, Screening, Dielectric function and its properties.

Phase diagram: Equilibrium transformation of first and second order, Equilibrium phase diagrams, phase rule, interpretation of phase diagrams, Substitutional solid solutions, Vegard's law, Intermediate phases, Hume-Rothery rules, Interstitial phases, (carbides, hydrides, nitrides, borides).

Section B

Disordered system: Disorder in condensed matter: substitutional, positional and topographical disorder. Dislocations and their role in plastic deformations and mechanical properties. Short and long range order., Electrical, magnetic and mechanical properties of glassy systems. Anderson model of random systems and electron localization, mobility edge, amorphous semiconductors and hopping conductivity.

Section C

Electronic properties: The Boltzmann transport equation and relaxation time, electrical conductivity of metals impurity scattering, ideal resistence at high and low temperature, Thermo-electric effect, thermal conductivity; the Wiedemann-Franz law.

Nuclear magnetic resonance (NMR), Mossbauer effect, Isomer shift, quadrupole splitting, Hyperfine (Zeeman) splitting, applications of Mossbauer spectroscopy: valence and coordination, site symmetry, magnetic behaviour, discussion in the context of ^{57}Fe, Measurement of dc and ac susceptibility (Squid, VSM), Atomic force microscopy (AFM), Scanning tunneling microscope (STM), Scanning electron microscope (SEM).

Recommended Books:

1. Callister W. D. (1991) *Materials Science and Engineering*: An Introduction, 9th Edition
2. Azaroff L. V.(1988) *Introduction to Solids* (Tata McGraw Hill)

3. Elliott S. R.(1990) *Physics of Amorphous Materials* (Langman Scientific & Technical Publisher)
4. March, Tosi and Street (1985) *Amorphous Solids and Liquid State* (Plenum)
5. Cullity B. D. and Stock S. R.(1978) *Elements of X-Ray Diffraction* (3rd Edition)

Suggested web-resources:

https://nptel.ac.in/courses/113102080/36

PHY 510 High Energy Physics - II

	L	T	P	C
Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

On successful completion of the course, Student will be able to:

- Possess knowledge of fundamental particles, fundamental interactions and the range and strength of these interactions with the concept of particle antiparticle or matter antimatter.

Section A

The scattering Cross Section in terms of Invariant Amplitude M. Decay Rate in terms of M, Invariant (Mandelstan) Variables.

An Electron Interacting with an Electromagnetic Field A_μ, Moller Scattering e+e- e+e-, the process e-u-→ e-u- and the process e-e-→u-u-, Helicity Conservation at high energies, Photons and their Polarization vectors, Summary of Feymnann rules for QED (no derivation).

Section B

The Process e-u-→ e-u- in the Laboratory Frame, Kinematics relevant to the Parton Model, Scattering of Electrons from a Static charge, probing a charge Distribution with Electrons, form Factors, Electron-proton Scattering. Proton Form Factors,lnelastic Electron Proton Scattering e p → e X, Bjorken Scaling, Partons and Bjorken Scaling, the Quarks with in the proton, Gluons and their evidence.

Section C

Parity violation and the V-A form of the weak current, Life time calculation for muon decay and pion decay, Charged current Neutrino-Electron Scattering, Neutrino Quark Scattering, First observation of weak neutral currents, Neutral currents and Neutrino quark scattering, the Cabbibbo Angle, weak mixing angles.

Recommended Books:

1. Helzen E. and Martin A. D. (2008) *Quarks and Leptons* (Wiley, India)

Suggested web-resources:

https://ocw.mit.edu/courses/physics/8-701-introduction-to-nuclear-and-particlae-physics-spring-2004/

https://ocw.mit.edu/courses/physics/8-811-particle-physics-ii-fall-2005/

PHY 515 Nonlinear Physics- II

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

On successful completion of the course, Student will be able to:

- Have an advanced knowledge of nonlinear dynamics.
- Understand the connection between nonlinear systems and their physical realization
- Understand the qualitative features of nonlinear dynamical systems.

Section A

Chaos in Hamiltonial systems: Hamilton's equation and Hamiltonian, phase space, Liouvelles theorem and phase space distribution, constants of motion and integrable systems, pendulum and simple harmonic oscillator, non-integrable systems, KAM theorem, possible orbits in conservative systems, period doubling and chaos in conservative systems, Henon-Heiles system, standard map, periodically driven undamped Duffing oscillator.

Section B

Integrability and notion of integrability: complete integrability, complex analytic integrability, detection of integrability: Painleve analysis, Painleve analysis and integrability of two coupled nonlinear oscillators, symmetries and integrability and its application to Henon Heiles system, a direct method for finding integral of motion, integrable systems with degrees of freedom more than two, integrable discrete systems and integrable dynamical systems on discret lattice.

Section C

Linear and nonlinear dispersive waves: linear waves, linear nondispersive wave propagation, linear dispersive propagation, fourier transform and solution of initial value problem, wave packet and dispersion, nonlinear dispersive systems, Cnoidal and solitary waves.

KDV equation and solitons: Scott Russel phenomenon and KdV equation, the Fermi-Pasta-Ulam numerical experiment on an harmonic lattices, asymptotic analysis and KdV equation, numerical experiments of Zabusky Kruskal, Hirota's bilinearization method.

Recommended Books:

1. Lakshmanan M. and Rajasekhar S. (2003) *Nonlinear Dynamics: Integrability, chaos and patterns* (Springer Verlag)
2. Hillborn R. C. (2000) *Chaos and nonlinear Dynamics* (Oxford University Press).
3. Guckenheimer J. and Holmes P. (1990) *Nonlinear oscillations, dynamical systems and bifurcation of vector fields* (Springer Verlag, New Yorke).
4. Gutzwiller M. C. (1990) *Chaos in classical and quantum mechanics* – (Springer Verlag, New York)

Suggested web-resources:

https://ocw.mit.edu/courses/mathematics/18-385j-nonlinear-dynamics-and-chaos-fall-2004/

https://nptel.ac.in/courses/115106059/

PHY 522 Physics of Nano-structures and Nanotechnology II

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

On successful completion of the course, Student will be able to:

- Understand the fundamental of nano-science & technology
- Able to apply the knowledge in material science, molecular electronics, synthetic biomolecular motors, DNA-based self-assembly, and manipulation of individual atoms via a scanning tunneling microscope

Section A

Properties of Nanomaterials-Mechanical properties, structural properties, Thermal Properties of Nanomaterials, coulomb blockade, resonant tunneling, Landaure resistance, Balastic transport of electron, Linear and nonlinear optical properties of semiconductors, surface Plasmon resonance in metal nanoparticles, Magnetic properties- Types of magnetic materials, nano magnetic materials (magnetic nanoparticles, magnetic multilayers, spin valve, magnetic tunnel junction, oxide materials).

Section B

Nano Materials: Carbon Nanotube- types of carbon nanotubes, Synthesis of nanotubes. Properties and structure of carbon nanotube. Porous silicon: Mechanism of porous formation, properties of porous silicon- electronic, optical, structural properties. Aerogels: types of aerogels, properties of aerogels. Zeolites- synthesis and properties of Zeolites.

Section C

Applications of nano devices: quantum well and quantum dot lasers, dc and RF squids, Single Electron transistor, Nanoscale MOSFET, spin based data storage , organic and polymer optoelectronic nanostructures: Polymer LED, Organic LED, Photovoltaic Polymers.

Recommended books:

1. Jain K. P. (1997) *Physics of semiconductor nanostructures* (Narosa Publishers).
2. Kulkarni S.K. (2007) *Nano technology; principle and practices* (Capital Publishing Company).
3. Garundmann D.M. and Ledentsov N.N. (1998) *Quantum dot heterostructures* (John- Wiley).
4. Delerue,C. , Lannoo M. (2006) *Nanostructures: theory and modeling* (Springer Verlag).
5. Kohler M. (2007) *Nanotechnology: An Introduction to Nanostructring Techniques* (W.Fritzsche, Wiley-VCH).
6. Wilson M., Kannangara K., Smith G., Simmons M. and Raguse B. (2002) *Nanotechnology: Basic Science & Emerging Technologies* by, (Chapman & Hall/CRC Press).

Suggested web-resources:

https://nptel.ac.in/courses/115101007/40

https://www.youtube.com/watch?v=jisTDmIk3Nw

https://www.youtube.com/watch?v=HFvPzXr7rxU

PHY 524 Plasma Physics - II

Max. Marks : 100 **L T P C**
(CA: 40 + ESA: 60) **4 0 0 4**

Learning Outcomes:

On successful completion of the course, Student will be able to:

- Understand the fourth state of matter.
- Have technological innovations stemming from plasma science.
- Understand the practical applications of plasma.

Section A

Waves in plasma : electron plasma waves, Ion Waves, Electrostatic electron oscillations perpendicular to B, upper hybrid oscillations, Electrostatic ion waves perpendicular to B, ion cyclotron waves, Lower hybrid oscillations, Electromagnetic waves in field free plasma, Electromagnetic waves perpendicular to B, Cut offs and resonances, Electromagnetic waves parallel to magnetic field, Hydromagnetic waves, Magnetosonic waves.

Section B

Kinetic theory, Boltzmann and Vlasov equations, Defivation of multifluid equations, Vlasov equatison, Linearization of Valsov Maxwell equations, High frequency plasma waves, Landau damping, A Physical derivation of Landau damping, Low frequency ion acoustic waves, Ion Landan damping.

Non-linear effects : Non-linear effects in plasmas, The Sagdeov potential, Derivation of KdV equation for ion acoustic waves, Soliton solution in one dimension, Elementary ideas about the ponderomotive force and parametric instability, Oscillating two stream instability, Non-linear Landau damping.

Section C

Controlled thermonuclear fusion and Other Plasma applications: Potentials and problems of controlled thermonuclear fusion, Ignition temperature and Lawson criteria.

Magnetic confinement: Simple discussion of Tokimak, stellarators, multipoles and Z pinch, Idea about inertial confinement and laser ftision, Methods of plasma heating and problems of fusion, Basic principle and working of MHD power generator, plasma application in industry, plasma torches.

Recommended Books:

1. Chen F.F. (1974) *An Introduction to Plasma Physics* (Plenum Press).
2. Davidson R.C. (1972) *Methods in Non-linear Plasma theory* (Academic Press).

Suggested web-resources:

https://nptel.ac.in/courses/115102020/

PHY 528 Solar Energy: Principles of Solar Thermal Devices

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

On successful completion of the course, Student will be able to:

- Understand principles of solar thermal devices and their applications.
- Have knowledge of solar thermal power (electricity) generation systems.

Section A

Heat conduction : Differential equation of heat conduction, Initial and boundary conditions, methods of solving heat conduction problems : separation of variable method for one dimension, The Greens' functions method, Integral transofrm method for finite and infinite ranges. Problems with and without internal heat generation, Numerical analysis of transient and periodic state of heat conduction Measurement techniques for thermal conductivity and their comparative study (static and dynamic), Guarded not plate method, Thermal probe, parallel wire.

Section B

Convective and Radiative Heat Transfer : Theory of convective heat transfer, Laminar and turbulent flow, Bopundary layer theory, Heat transfer in duct, heat exchangers : basic thermal sign methods, Theory of heat pipes, Design considerations, Applications of heat pipes, Direct and diffused thermal radiation, Radiative properties of real surfaces, Radiation exchange between surfaces, Atmosphereic attenuation, solar radiation measurements solar radiation geometry.

Solar Eenrgy collectors : Flat Plate solar energy collectors, Selective absorber surfaces, Transparatent plates, Collector energy losses, Thermal analysis of collectors, Air heating collectors, Collector performance testing. Concentrating collectors, Thermal analysis of concentrating collectors, Tracking requirements.

Section C

Thermal Energy Storage and Solar Thermal Devices : Storage of solar energy, Water storage, Straification fo water storage, Packed bed storage, Phase change storage, Solar pond, Chemical storage, Solar space conditioning- Energy requirements in buildings, Passive system architecture,Performance and design; coiling processes, Vapor compression refrigeration cycle, Absorption refrigeration cycel, Performance of solar absorption air conditioning, Solar energy process economics.

Recommended Books:

1. Ozisik M. N. (2010) *Heat Conduction* (John Wiley & Sons).
2. Warren M. R., Harnou J. P. and Ganic F. N. (2010) *Hand Book of Heat transfer Application*
3. Carslas H.S., and Jsegar J.C. (1959) *Conduction of Heat in Solids* (Oxford Clarendon Press).
4. Luikov A (1999) *Heat and Mass Transfer* (Mir Publichers Moscow).
5. Parrot J.E. and Stuckers A. D. (2002) *Thermal conductivity of Solids* (Pion Limited, London).
6. Dluffie and Backman (2009) *Solar energy Thermal Processs* (Wiley & Sons, New York).
7. Haieh J. S. (2010) *Solar Energy Engg*. (Prentice Hall, New Jersey).
8. Sukhatme S.P (2002) *Solar Energy* (Tata McGraw Hill, New Delhi).

Suggested web-resources:

https://nptel.ac.in/courses/112105051/

https://nptel.ac.in/courses/112105050/

PHY 533 Biophysics-II

	L	T	P	C
Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

On successful completion of the course, Student will be able to:

- Understand the concepts of physical principles in the biomolecular systems.
- Know Properties and conformations of biomolecules.
- Understand the interaction between physics and biology.

Section A

Physics of macromolecules: Biological polymers, modeling polymers as elasticity models, Random walk model, radius of gyration, freely jointed chain, calculation of the distribution of end-to-end distances, statistical segment, persistence length, relation to characteristic ratio, worm like chain, behavior of chain dimension, DNA Elasticity, Application of Porod-Kraty model to DNA.

Protein folding: Anfinsen's thermodynamic hypothesis, Case study: Ribonuclease A,renaturation and denaturation, mechanism of disulphide exchange, determinants of protein folding, Levinthal's paradox, classical view of protein folding, the hydrophobic collapse, Energy landscape theory, Protein Folding problem as a NP-hard problem.

Section B

Self assembly and membrane equilibria: Self assembly in miscelles as monolayers and bilayers, Thermodynamics of miscelle formation, co-operativity, packing parameter, Tanford's free energy model, Packing model, influence of tail packing, Fluid mosaic model, Langmuir adsorption model.

Electrical conduction in the nervous system: Structure of the neuron, Hodgkin-Huxley model and generation of action potential, Nernst relation in membrane potentials, Donnan equilibrium, ion pumping, voltage gating.

Transport in cells: Diffusion, Fick's law, cells with sources, low Reynolds-number, friction in fluids, Transport across cells - osmosis.

Section C

Blood flow: Blood as non-Newtonian fluid, Blood flow models, Navier Stokes equation, Dissipative particle dynamics, Erythrocyte model, elastic model.

Energy in muscle: Cytoskeleton, Muscle Contraction, biopolymers of the cytoskeleton,Tubulin, microtubules, associated protein, micro filaments, actin and Myosin. Molecular motors, Kinesin and Dyenin. Sliding filament model of contraction, ATP and muscle contraction, stochastic model of contraction.

Radiation Physics: Dosimetery, Photon interaction coefficients, Relations between exposure, Kerma and absorbed dose, Measurement of exposure, Bragg-Gray Cavity theory, determination of absorbed dose in a medium, radiotherapy, geometrical factors, specification of dose ratios, nuclear medicine.

Recommended Books:

1. Tuszynski, J. A., & Kurzynski, M. (2003). *Introduction to molecular biophysics*. CRC press.

2. Schlick, T. (2010). *Molecular modeling and simulation: an interdisciplinary guide: an interdisciplinary guide* (Vol. 21). Springer Science & Business Media.
3. Nelson, P. (2004). *Biological physics*. New York: WH Freeman.
4. Cantor, C. R., & Schimmel, P. R. (1980). *Biophysical chemistry: Part III: the behavior of biological macromolecules*. Macmillan.
5. Smith, F. A. (2000). *A primer in applied radiation physics*. World Scientific Publishing Company.

Reference Books:

1. Van Holde, K. E., Johnson, W. C., & Ho, P. S. (2006). *Principles of physical biochemistry*.
2. Jensen, J. H. (2010). *Molecular modeling basics*. CRC Press.
3. Voet, D., Voet, J. G., & Pratt, C. W. (2013). *Fundamentals of biochemistry: life at the molecular level* (No. 577.1 VOE). Hoboken: Wiley.

Suggested Web-resources:

https://www.coursera.org/learn/dynamicalmodeling?specialization=systems-biology

Reading Elective

PHY 536R Optical Materials and Devices

	L	T	P	C
Max. Marks : 100	**L**	**T**	**P**	**C**
ESA:100	**0**	**0**	**4**	**2**

Learning Outcomes:

On successful completion of the course, Student will be able to:

- Understand the fundamental operating principles of photodevices.
- Have the knowledge about LED and heterojunction laser materials selection and design.
- Have the knowledge about fundamentals of organic electronics and liquid crystal displays.

This course covers the fundamentals of modern optical devices and systems from a practical point of view. Its goal is to help the student develop a thorough understanding of the underlying physical principles such that device and system design and performance can be predicted, analyzed, and understood. Course includes Optoelectronic materials, Introduction: LEDs, LASERs, photodetectors, solar cells; LEDs, Introduction to Lasers, Semiconductor Lasers and Heterostructures, Organic Electronics, Liquid Crystal Displays, Optical Fibers. An Overview of Photonic Systems, photonic integrated circuit in telecommunication and sensors.

Recommended Books:

1. Kasap, S. O. (2006). *Principles of electronic materials and devices* (Vol.2). New York: McGraw-Hill.
2. Sze, S. M. (2008). *Semiconductor devices: physics and technology*. John Wiley & Sons.
3. Saleh, B. E., Teich, M. C., & Saleh, B. E. (1991). *Fundamentals of photonics* (Vol. 22). New York: Wiley.

Suggested web-resources:

https://www.edx.org/course/optical-materials-devices-mitx-3-15-2x-0

PHY 539R Solar Energy: Photovoltaic Systems

Max. Marks : 100	**L**	**T**	**P**	**C**
ESA:100	**0**	**0**	**4**	**2**

Learning Outcomes:

On successful completion of the course, Student will be able to:

- Learn the principles behind the potential loss mechanisms in photovoltaic devices
- Learn the semiconductor physics necessary to understand solar cell performance and engineering
- Have the knowledge about optics and light management tools necessary for optimal solar cell design
- Model all aspects of a working solar cell, understanding the efficiency limits and design rules

This course includes Introduction to photovoltaic (PV) systems. Historical development of PV systems. Overview of PV usage in the world, Solar energy potential for PV, irradiance, solar radiation and spectrum of sun, geometric and atmospheric effects on sunlight, Photovoltaic effect, conversion of solar energy into electrical energy, behavior of solar cells, Solar cells, basic structure and characteristics: Single-crystalline, multicrystalline, thin film silicon solar cells, emerging new technologies, Electrical characteristics of the solar cell, equivalent circuit, modeling of solar cells including the effects of temperature, irradiation and series/shunt resistances on the open-circuit voltage and short-circuit current.

Recommended Books:

1. Green, M. A. (1982). *Solar cells: operating principles, technology, and system applications*. Englewood Cliffs, NJ, Prentice-Hall, Inc., 1982. 288 p.
2. Duffie, J. A., & Beckman, W. A. (2013). *Solar engineering of thermal processes*. John Wiley & Sons.

Suggested web-resources:

https://www.edx.org/course/solar-energy-photovoltaic-pv-energy-delftx-pv1x-0

https://www.edx.org/course/solar-energy

ELE 414R Introduction to Photonics

Max. Marks : 100	**L**	**T**	**P**	**C**
ESA:100	**0**	**0**	**4**	**2**

Learning Outcomes:

On successful completion of the course, Student will be able to:

- Learn the fundamental principles of photonics and light-matter interactions.
- Develop the ability to formulate problems related to photonic structures/processes and analyze them.
- Understand processes that help to manipulate the fundamental properties of light.

This course covers the fundamentals of photonics and systems from a practical point of view. Its goal is to help the student develop a thorough understanding of the underlying physical principles such that explain the light propagation through optical fibers and explain the various light sources and optical detectors with design fiber optic transmitter and receiver system

Recommended Books:

1. Nilsson, J. W., & Riedel, S. (2010). *Electric circuits*. Prentice Hall Press.
2. Horowitz, P., & Hill, W. (1989). *The art of electronics*. Cambridge Univ. Press.
3. Hayes, M. H. (2009). *Statistical digital signal processing and modeling*. John Wiley & Sons.

4. Hayes, M. H. (1998). *Schaum's outline of digital signal processing.* McGraw-Hill, Inc..

Suggested web-resources:

https://www.coursera.org/learn/electronics

https://swayam.gov.in/course/4438-basic-electronics

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