COURSE OUTLINE BRIEFS

DEPARTMENT OF PHYSICS

SARGODHA UNIVERSITY
Pathway to Progress

FACULTY OF SCIENCES

OVERVIEW

Physics deals with the structure of matter and the interactions between the fundamental constituents of the observable universe. In the broadest sense, physics is concerned with all aspects of nature on both the macroscopic and submicroscopic levels.

The Physics Department of the University offers PhD, MPhil, MSc and BS programs while our graduates are among the highly graded students in various universities pursing higher studies. It has 13 PhD and 6 MPhil qualified faculty members who are expert in different disciplines of physics and committed to providing quality education.

To provide maximum teaching and research facilities to the young scholars with the aim to produce scientists with a highly rational approach, laboratories of the department are being modernized and equipped with the latest and sophisticated instruments and apparatus. The establishment of plasma physics laboratory and crystallography laboratory is a milestone to research oriented education in the field of basic sciences as well as plasma physics, mineralogy and pharmaceutical industry.

The absorption of our students in various top level organizations like AWC, PAEC, PIAS and their successful selection through the Public Service Commissions have proved the quality of education being imparted in this department.

Academic Programs Offered

1. BS Physics
2. MSc Physics
3. Phil Physics
4. PhD Physics

BS Physics

Eligibility: At least 45% marks in intermediate or equivalent with Physics and Mathematics.

Duration: 04 Year Program (08 Semesters)

Degree Requirements: 132 Credit Hours

Semester-1

Course Code	Course Title	Credit Hours
PHYS-5101	Mechanics-I	4(3+1)
PHYS-5102	Waves and Oscillations	3(3+0)
MATH-5120	Applications of Differentials	3(3+0)
URCE-5101	Grammar	3(3+0)
URCP-5196	Pakistan Studies	2(2+0)

Semester-2

PHYS-5103	Mechanics-II	4(3+1)
PHYS-5104	Electricity and Magnetism-I	3(3+0)
MATH-5121	Techniques of Integration	3(3+0)
URCE-5102	Language Comprehension & Presentation Skills	3(3+0)
URCI-5105	Islamic Studies	2(2+0)

Semester-3

PHYS-5105	Electricity and Magnetism-II	3(3+0)
PHYS-5106	Fundamentals of Quantum Mechanics	3(3+0)
PHYS-5107	Physics Lab-I	3(0+3)
MATH-5122	Calculus	3(3+0)
MATH-5123	Ordinary Differentials Equations	3(3+0)
URCE-5103	Academic Writing	3(3+0)

Semester-4

PHYS-5108	Basics of Electronics and Nuclear Physics	3(3+0)
PHYS-5109	Theory of Thermodynamics	3(3+0)
PHYS-5110	Physics Lab-II	3(0+3)
MATH-5124	Vectors and Tensors Analysis	3(3+0)
MATH-5125	Linear Algebra	3(3+0)
STAT-5125	Theory of Error Analysis	3(3+0)

Semester-5

PHYS-6111	Methods of Mathematical Physics-I	3(3+0)
PHYS-6112	Classical Mechanics-I	3(3+0)

PHYS-6113	Electrodynamics-I	3(3+0)
PHYS-6114	Electronics	3(3+0)
PHYS-6115	Electronics Lab	3(3+0)

Semester-6

PHYS-6116	Methods of Mathematical Physics-II	3(3+0)
PHYS-6117	Classical Mechanics–II	3(3+0)
PHYS-6118	Electrodynamics-II	3(3+0)
PHYS-6119	Quantum Mechanics-I	3(3+0)
PHYS-6120	Solid State Physics-I	3(3+0)
PHYS-6121	Modern Physics Lab	3(0+3)

Semester-7

PHYS-6122	Statistical Mechanics	3(3+0)
PHYS-6123	Atomic Physics	3(3+0)
PHYS-6124	Plasma Physics	3(3+0)
PHYS-6125	Quantum Mechanics-II	3(3+0)
PHYS-6126	SolidState Physics-II	3(3+0)
PHYS-61xx	Optional Course[a]/Thesis[b]	3(3+0)

Semester-8

PHYS-6127	Computational Physics	3(3+0)
PHYS-6128	Laser Physics	3(3+0)
PHYS-6129	Relativity and Cosmology	3(3+0)
PHYS-6130	Nuclear and Elementary Particle Physics	3(3+0)
PHYS-61xx	Optional Course[a]/Project[c]	3(3+0)

Optional Courses

PHYS-6131	Advanced Electronics	3(3+0)
PHYS-6132	Physical and Geometrical Optics	3(3+0)
PHYS-6133	Physics of Nanotechnologies	3(3+0)
PHYS-6134	Methods of Experimental Physics	3(3+0)
PHYS-6135	Advanced Electronics LAB[d]	3(0+3)
PHYS-6136	Introduction to Quantum Computing	3(3+0)
PHYS-6137	Particle Physics	3(3+0)
PHYS-6138	Project[c]	3(3+0)

a. Student may take two optional courses (Optional course-I in Semester VII and Optional course-II in Semester VIII) from courses offered at the department.
b. A Thesis of 06 Cr Hrs can be opted if offered at the department.
c. A Project of 03 credit hours can also be opted in the 8th semester.
d. Advanced Electronics LAB can be opted only if Advanced Electronics is taken.

MSc Physics

Eligibility: At least 45% marks in BSc with one of the following combinations (with at least 45% marks in Physics)

i. Physics + Math A + Math B & ii. Physics + Math General + any other Science subject

Duration: 02 Year Program (04 Semesters) Degree Requirements: 66 Credit Hours

Semester-1

PHYS-6111	Methods of Mathematical Physics-I	3(3-0)
PHYS-6112	Classical Mechanics-I	3(3-0)
PHYS-6113	Electrodynamics-I	3(3-0)
PHYS-6114	Electronics	3(3-0)
PHYS-6121	Modern Physics Lab	3(3-0)

Semester-2

PHYS-6116	Methods of Mathematical Physics-II	3(3-0)
PHYS-6117	Classical Mechanics–II	3(3-0)
PHYS-6118	Electrodynamics-II	3(3-0)
PHYS-6119	Quantum Mechanics-I	3(3-0)
PHYS-6120	Solid State Physics-I	3(3-0)
PHYS-6115	Electronics Lab	3(0-3)

Semester-3

PHYS-6122	Statistical Mechanics	3(3-0)
PHYS-6123	Atomic Physics	3(3-0)
PHYS-6124	Plasma Physics	3(3-0)
PHYS-6125	Quantum Mechanics-II	3(3-0)
PHYS-6126	SolidState Physics-II	3(3-0)
PHYS-61xx	Optional Course[a]/Thesis[b]	3(3-0)

Semester-4

PHYS-6127	Computational Physics	3(3-0)
PHYS-6128	Laser Physics	3(3-0)
PHYS-6129	Relativity and Cosmology	3(3-0)
PHYS-6130	Nuclear and Elementary Particle Physics	3(3-0)
PHYS-61xx	Optional Course[a]/Thesis[b]	3(3-0)

Optional Courses

PHYS-6131	Advanced Electronics	3(3-0)
PHYS-6132	Physical and Geometrical Optics	3(3-0)
PHYS-6133	Physics of Nanotechnologies	3(3-0)
PHYS-6134	Methods of Experimental Physics	3(3-0)
PHYS-6135	Advanced Electronics LAB[c]	3(0-3)
PHYS-6136	Introduction to Quantum Computing	3(3-0)
PHYS-6137	Particle Physics	3(3-0)

a. Student may take two optional courses (Optional course-I in Semester III and Optional course-II in Semester IV) from courses offered at the department.
b. A Thesis of 06 Cr Hrs can be opted if offered at the department.
c. Advanced Electronics LAB can be opted only if Advanced Electronics is taken.

MPhil Physics

Eligibility: MSc Physics/BS Physics (4-Year) or equivalent (16 years of education) in the relevant field from HEC recognized institution withat least CGPA 2.00 out of 4.00+subject based entry test (minimum 50% marks) + interview
Duration: 02 Year Program (04Semesters)
Degree Requirements: 30 Credit Hours (24 Credit Hours Course Work + 06 Credit Hours Thesis)

Semester-1

PHYS-7101	Methods of Mathematical Physics	3(3-0)
PHYS-7102	Methods and Techniques of Experimental Physics	3(3-0)
PHYS-71xx	Optional Course-I	3(3-0)
PHYS-71xx	Optional Course-II	3(3-0)

Semester-2

PHYS-71xx	Optional Course-I	3(3-0)
PHYS-71xx	Optional Course-II	3(3-0)
PHYS-71xx	Optional Course-III	3(3-0)
PHYS-71xx	Optional Course-IV	3(3-0)

Semester 3-4

PHYS-7114	MPhil Thesis	6 (6-0)

Optional Courses

PHYS-7103	Condensed Matter Physics	3(3-0)
PHYS-7104	Magnetism in Low dimensions	3(3-0)
PHYS-7105	Material Science	3(3-0)
PHYS-7106	X-ray Crystallography	3(3-0)
PHYS-7107	Pulsed Laser Deposition for Thin Film Growth	3(3-0)
PHYS-7108	Low temperature plasmas	3(3-0)
PHYS-7109	Chaos, Stability and Control	3(3-0)
PHYS-7110	Introduction to DFT	3(3-0)
PHYS-7111	Growth and Characterization of Solids	3(3-0)
PHYS-7112	Atomic and Molecular Spectroscopy	3(3-0)
PHYS-7113	Ion Physics (Methods and Instruments)	3(3-0)

- The students of M. Phil program will be offered four courses including the two compulsory courses in the first semester and four courses in the second semester from the list of the optional courses.
- Courses will be offered depending upon the recourses of the department.

PhD Physics

Eligibility: MPhil Physics/MS Physicsor equivalent (18 years of education)in the relevant field from HEC recognized institution with at least CGPA 3.00 out of 4.00 or Ist division in annual system+subject based entry test (minimum 70% marks) + interview
Duration: 03 Year Program (06 Semesters)
Degree Requirements: 18 Credit Hours Course Work + Thesis

Semester-1

PHYS-81xx	Optional Course-I	3(3-0)
PHYS-81xx	Optional Course-II	3(3-0)
PHYS-81xx	Optional Course-III	3(3-0)

Semester-2

PHYS-81xx	Optional Course-I	3(3-0)
PHYS-81xx	Optional Course-II	3(3-0)
PHYS-81xx	Optional Course-III	3(3-0)

Semester 3-6

PHYS -8110	PhD Thesis

Optional Course

PHYS-8101	Quantum Field Theory	3(3-0)
PHYS-8102	Plasma-Wall Interaction in Fusion Reactors	3(3-0)
PHYS-8103	Magnetization reversal and magnetization dynamics	3(3-0)
PHYS-8104	Classical and Quantum Statistical Physics	3(3-0)
PHYS-8105	Advance Material Science	3(3-0)
PHYS-8106	Nonlinear Physics	3(3-0)
PHYS-8107	Laser Spectroscopy: Experimental Techniques	3(3-0)
PHYS-8108	Electromagnetic Theory	3(3-0)
PHYS-8109	Plasma Processing and Technology	3(3-0)

- A PhD student will have to complete 18 Cr. H. courses in addition to 24 Cr. H. courses of M. Phil.
- A PhD student can opt optional courses of M. Phil towards the fulfillment of the requirement of the course work if he/she did not study these courses during his/her M. Phil and vice versa.
- The supervisor may recommend a PhD student to opt courses of his/her relevant field from approved courses of M. Phil./PhD offered by Department of Chemistry, Department of Mathematics or Department of Computer Science & Information Techonology to fulfill his/her PhDcoursework condition.
- The optional courses will be offered depending upon the resources of the department.

BS
PHYSICS

PHYS-5101 **Mechanics- I** **4(3+1)**

Mechanics is all about motion of body. It deals with forces, motion, stress, strain and further to the laws of motion in inertial frames specifically. This course also provides the students a broad understanding of the physical principles of the classical dynamics, to describe mechanical events that involve forces acting on macroscopic objects with quantitative skills, to motivate them to think creatively and critically about scientific problems and experiments (thought as well real-life). A student studying this course will understand classical physics and will also develop the skills to apply principles to the practical life problems. Students are encouraged to share their thinking with teachers and the other students to examine different problem-solving strategies.

Contents

1. Measuring things, displacement, average velocity and speed, acceleration, constant acceleration, free fall acceleration, graphical integration in motion analysis
2. Vectors and their components, adding vectors by components, multiplying vectors
3. Unit vector, vector representation of quantities, projectile motion, uniform circular motion
4. Relative motion in one dimension, relative motion in two dimensions
5. Newton's first and second law, some particular forces, applying newton laws, friction
6. Drag force, uniform circular motion, kinetic energy, work and kinetic energy
7. Work done by gravitational force, work done by a spring force
8. Work done by a general variable force, power, potential energy, conservation of energy
9. Conservation of mechanical energy, work done on a system by an external force
10. Conservation of energy, center of mass, newton's second law for system of particles
11. Linear momentum, collision and impulse, momentum and kinetic energy in collision
12. Elastic collision in one dimension, collisions in one/two dimensions
13. Conservation of linear momentum and system with varying mass
14. Modulus of rigidity by static & dynamic method (maxwell's needle, barton's apparatus)
15. To determine the value of "g" by compound pendulum/kater's pendulum
16. To study the conservation of energy (hook's law)
17. To determine elastic constants by spiral springs
18. To study the laws of vibration of stretched string using sonometer
19. Modulus of rigidity by static & dynamic method (maxwell's needle, barton's apparatus)

Recommended Texts

1. Halliday, D., Resnick, R. & Walker, J. (2014). *Fundamentals of physics* (10th ed.). New York: Wiley.
2. Halliday, D., Resnick, R. & Krane, K. S. (2003). *Physics* (5th ed.). New York: Wiley.

Suggested Readings

1. Young, H. D., Freedman, R. A. & Ford, A. L. (2019). *University physics* (15th ed.). New York: Pearson.
2. Serway, R. A. & Jewelt, J. W. (2014). *Physics for scientist and engineers* (9th ed.). New York: Brooks/Cole.
3. Melissinos, A.C. (2008). *Experiments in modern physics.* New York: Academic press.

PHYS-5102 Waves and Oscillations 3(3+0)

This course provides the students with a broad understanding of the physical principles of the oscillations, to help them develop critical thinking and quantitative reasoning skills, to empower them to think creatively and critically about scientific problems and experiments with the help of mathematics. This course will provide them with the concepts and mathematical tools necessary to understand and explain a broad range of vibrations and waves. Students will learn that waves come from many interconnected (coupled) objects when they are vibrating together. We will discuss many of these phenomena, along with related topics, including mechanical vibrations and waves, sound waves, electromagnetic waves, optics, and gravitational waves.

Contents

1. S.h.m & its applications, energy consideration in shm
2. Shm & uniform circular motion
3. Combinations of harmonic motion
4. Damped harmonic oscillator
5. Forced oscillation
6. Driven harmonic oscillator, resonance
7. Mechanical waves, traveling waves, linear wave equation, power & intensity in wave motion
8. Principle of superposition, standing waves, interference of waves, beats
9. Doppler effect & its applications, supersonic and shock waves
10. Measurement of speed of light by roemer's and fizeau's methods, reflection, refraction
11. Huygens's principle and its applications to reflection and refraction
12. Fermat's principle, conditions for interference
13. Young's double slit experiment, intensity distribution in double slit interference pattern, phasors
14. Interference from thin film
15. Introduction to diffraction pattern, single slit diffraction pattern
16. Intensity in single slit diffraction pattern using phasor, diffraction grating
17. X-ray diffraction
18. Polarization by selective absorption
19. Reflection
20. Double refraction, scattering & optical activity

Recommended Texts

1. Resnick, R., Halliday, D. & Krane, K. S. (2002). *Physics (*5th ed.) New York: Wiley.
2. Halliday, D., Resnick, R. & Walker, J. (2014). *Fundamental of physics* (10th ed.) New York: Wiley.

Suggested Readings

1. Sears, F. W., Zemansky, M. W. & Young, H. D. (2000). *University physics* (8th ed.) Massachusetts: Addison-Wesley.
2. Alonso, M. & Finn, E. J. (1999). *Physics*. Massachusetts*:* Addison-Wesley.
3. Serway, R. A. & Jewelt, J. W. (2004). *Physics for scientists and engineers* (6th ed.). New York: Thomson Brooks.t

MATH-5120 **Applications of Differentials** **3(3+0)**

This course is an introduction to Applications of Differentials. This prepares the way for calculus by discussing the basic ideas concerning functions, their graphs, and ways of transforming and combining them. We stress that a function can be represented indifferent ways: by an equation, in a table, by a graph, or in words. We look at the main types of functions that occur in calculus and describe the process of using these functions as mathematical models of real-world phenomena. We study a variety of models in physics and engineering, which use in Calculus serving as the foundation of advanced subjects in all areas of mathematical physics. The sequence, equally, emphasizes basic concepts and skills needed for mathematical manipulation. It focuses on the study of functions of a single variable. It is appropriate to begin our study of calculus by investigating limits and their properties. The special type of limit that is used to find tangents and velocities gives rise to the central idea in differential calculus, the derivative. In this course interpret derivatives as slopes and rates of change, how to estimate derivatives of functions given by tables of values, how to graph derivatives of functions that are defined graphically, use the definition of a derivative to calculate the derivatives of functions defined by formulas, develop rules for finding derivatives without having to use the definition directly. These differentiation rules enable us to calculate with relative ease the derivatives of polynomials, rational functions, algebraic functions, exponential and logarithmic functions, and trigonometric and inverse trigonometric functions. We then use these rules to solve problems involving rates of change and the approximation of functions. The study of applications of differentiation in greater depth. Here we learn how derivatives affect the shape of a graph of a function and how they help us locate maximum and minimum values of functions. Many practical problems require us to minimize a cost or maximize an area or somehow find the best possible outcome of a situation. We investigate the optimal shape of a can and to explain the location of rainbows in the sky.

Contents

1. Limits: limit of a function, infinite limits, the squeeze theorem, the sum law
2. Continuity, the intermediate value theorem, horizontal asymptotes
3. Derivatives and rates of change
4. Derivatives as a function, derivatives of polynomials and exponential functions
5. Power rule, the product and quotient rules, derivatives of trigonometric functions
6. The chain rule, implicit differentiation, exponential growth and decay
7. Hyperbolic functions. applications of differentiations
8. The extreme value theorem, the mean value theorem, concavity test
9. Indeterminate forms and l'hospital rule, curve sketching, optimization problems

Recommended Texts

1. Stewart, J. (2016). *Calculus early transcendentals (8th* ed.). New York: Brooks/Cole.
2. Anton, H., Bivens, I. C. & Davis, S. (2016). *Calculus* (11th ed.). New Jersey: Wiley.

Suggested Readings

1. Thomas, G. B. (2015). *Calculus (*12th ed.). India: Pearson Edition.
2. Goldstein, L. J., Lay, D. C., Schneider, D. I. & Asmar, N. H. (2017). *Calculus & its applications* (14th ed.). London: Pearson.

URCE-5101 **Grammar** **3(3+0)**

The course introduces the students to the underlying rules to acquire and use language in academic context. The course aims at developing grammatical competence of the learners to use grammatical structures in context in order to make the experience of learning English more meaningful enabling the students to meet their real life communication needs. The objectives of the course are to, reinforce the basics of grammar, understand the basic meaningful units of language, and introduce the functional aspects of grammatical categories and to comprehend language use by practically working on the grammatical aspects of language in academic settings. After studying the course, students would be able to use the language efficiently in academic and real life situations and integrate the basic language skills in speaking and writing. The students would be able to work in a competitive environment at higher education level to cater with the long term learners' needs.

Contents

1. Parts of speech
2. Noun and its types
3. Pronoun and its types
4. Adjective and its types
5. Verb and its types
6. Adverb and its types
7. Prepositions and its types
8. Conjunction and its types
9. Phrases and its different types
10. Clauses and its different types
11. Sentence, parts of sentence and types of sentence
12. Synthesis of sentence
13. Conditional sentences
14. Voices
15. Narration
16. Punctuation
17. Common grammatical errors and their corrections

Recommended Texts

1. Eastwood, J. (2011). *A basic English grammar*. Oxford: Oxford University Press.
2. Swan, M. (2018). *Practical English usage* (8th ed.). Oxford: Oxford University Press.

Suggested Readings

1. Thomson, A. J., & Martinet, A. V. (1986). *A practical English grammar*. Oxford: Oxford University Press
2. Biber, D., Johansson, S., Leech, G., Conrad, S., Finegan, E., & Quirk, R. (1999). *Longman grammar of spoken and written English*. Harlow Essex: MIT Press.
3. Hunston, S., & Francis, G. (2000). *Pattern grammar: A corpus-driven approach to the lexical grammar of English*. Amsterdam: John Benjamins.

URCP-5196 **Pakistan Studies** **3(3+0)**

The course is designed to acquaint the students of BS Programs with the rationale of the creation of Pakistan. The students would be apprised of the emergence, growth and development of Muslim nationalism in South Asia and the struggle for freedom, which eventually led to the establishment of Pakistan. While highlighting the main objectives of national life, the course explains further the socio-economic, political and cultural aspects of Pakistan's endeavours to develop and progress in the contemporary world. For this purpose, the foreign policy objectives and Pakistan's foreign relations with neighbouring and other countries are also included. This curriculum has been developed to help students analyse the socio-political problems of Pakistan while highlighting various phases of its history before and after the partition and to develop a vision in them to become knowledgeable citizens of their homeland.

Contents

1. Contextualizing pakistan studies
2. Geography of pakistan: geo-strategic importance of pakistan
3. Freedom movement (1857-1947)
4. Pakistan movement (1940-47)
5. Muslim nationalism in south asia
6. Two nations theory
7. Ideology of pakistan
8. Initial problems of pakistan
9. Political and constitutional developments in pakistan
10. Economy of pakistan: problems and prospects
11. Society and culture of pakistan
12. Foreign policy objectives of pakistan and diplomatic relations
13. Current and contemporary issues of pakistan
14. Human rights: issues of human rights in pakistan

Recommended Texts

1. Kazimi, M. R. (2007). *Pakistan studies.* Karachi: Oxford University Press.
2. Sheikh, Javed Ahmad (2004). *Pakistan's political economic and diplomatic dynamics.* Lahore: Kitabistan Paper Products.

Suggested Readings

1. Hayat, Sikandar (2016). *Aspects of Pakistan movement.* Islamabad: National Institute of Historical and Cultural Research.
2. Kazimi, M. R. (2009). *A concise history of Pakistan.* Karachi: Oxford University Press.
3. Talbot, Ian (1998). *Pakistan: A modern history*. London: Hurst and Company.

PHYS-5103 **Mechanics-II** **4(3+1)**

Mechanics-II is the continuation of mechanics-I. This course deals with the behavior of the particle in rotational motion. The aim of the course is to familiarize the students with problem solving techniques when the particle is in rotational motion. The first part of this course is the rotational analog of mechanics-I. We have equation of motions for rotational motion, newton's law in rotational motion. This includes the motion of planets around the sun and laws governing those motions, formation of black holes in the universe due to gravitaion and gravitation in planets. The second part of this course concerns with laws of fluids and some useful application of these laws in Automobile industries. The last part deals with new theory which was developed in the beginning of 20th century, called special theory of relativity. Students will be able to understand the basics of this theory and its consequences like time and length variation etc.

Contents

1. Rotational dynamics and moment of inertia, principles of parallel and perpendicular axis theorem, determination of moment of inertia of various shapes, rotational dynamics of rigid bodies and its effect on the application of torque
2. Angular momentum and its conservation, effect of torque on the angular momentum
3. Measurement of gravitational constant, free fall acceleration and gravitational force, gravitational effect of spherical mass distribution, the motion of planets and kepler laws in detail, motion of satellite and its energy consideration in planetary and satellite motion
4. Bulk properties of matter
5. Fluid statistics and fluid dynamics
6. Inertial and non-inertial frames of references, postulates of special theory of relativity, galilean transformation equations and lorenz transformation and its consequences, transformation of velocities and variation of mass with velocity, mass energy relation and its importance and relativistic energy and momentum, general theory of relativity
7. Determination of moment of inertia of a solid/hollow cylinder and a sphere etc
8. To determine horizontal/vertical distance by sextant
9. To determine wavelength of light by diffraction grating
10. Measurement of the rotation of plane of polarization
11. Surface tension of water by capillary tube method

Recommended Texts

1. Halliday, D. Resnick, R. & Walker, J. (2014). *Fundamentals of physics* (10th ed.). New York: Wiley.
2. Halliday, D. Resnick, R. & Krane, K. S. (2003). *Physics* (5th ed.). New York: Wiley.

Suggested Readings

1. Young, H. D., Freedman, R. A. & Ford, A. L. (2019). *University physics* (15th ed.). New York: Pearson.
2. Serway, R. A. & Jewelt, J. W. (2014). *Physics for scientist and engineers* (9th ed.). New York: Brooks/Cole.
3. Musaddiq, M. H. (2008). *Experimental physics*. Lahore: Allied Book Center.
4. Melissinos, A. C. (2008). *Experiments in modern physics.* New York: Academic press.

PHYS-5104 **Electricity and Magnetism-I** **3(3+0)**

Electricity and Magnetism-I is an introduction to electromagnetic fields and forces. Electromagnetic forces quite literally dominate our everyday experience. The reason you do not fall through the floor to the center of the earth as you are reading this is because you are floating on (and held together by) electrostatic force fields. However, we are unaware of this in a visceral way, in large part because electromagnetic forces are so enormously strong than gravity. Because of the strength of electromagnetic forces, any small imbalance in net electric charge gives rise to enormous forces that act to try to erase that imbalance. The aim of this course is to tease out the laws of electromagnetism from our everyday experience by specific examples of how electromagnetic phenomena manifest themselves.

Contents

1. Electric charge properties, charge quantization, charge conservation, conductors and insulators
2. The electric field, electric field lines
3. Coulombs law, the electric field due to a point charge, electric dipole, a line of charge and charged disk, a point charge and dipole in an electric field
4. Flux, flux of an electric field, gauss' law, gauss' law, a charged isolated conductor
5. Applying gauss' law: cylindrical symmetry, planar symmetry, spherical symmetry
6. Electric potential energy, electric potential, equipotential surfaces, calculating the potential from the field, potential due to a point charge, dipole, and group of point charges
7. Potential due to a continuous charge distribution, calculating the field from the potential
8. Capacitors and capacitance, calculating the capacitance for various geometries
9. Capacitors in parallel and in series, energy stored in an electric field, capacitor with a dielectric, dielectrics: an atomic view, dielectrics and gauss' law
10. Electric current, current density, resistance and resistivity, microscopic and macroscopic forms of ohm’s law
11. Energy transfer in electric circuit, power in electric circuits, semiconductors, superconductors
12. Calculating current in a single loop circuit by using kirchhoff laws, other single-loop circuits, potential difference between two points
13. Multiloop circuits, circuit analysis, growth and decay of current in rc-circuits and its analytical treatment

Recommended Texts

1. Halliday, D., Resnick, R. & Walker, J. (2014). *Fundamental of Physics* (10^{th} ed.). New York: Wiley.
2. Halliday, D., Resnick, R. & Krane, K. S. (2003). *Physics* (5^{th} ed.). New York: Wiley.

Suggested Readings

1. Young, H. D., Freedman, R. A. & Ford, A. L. (2019). *University physics* (15^{th} ed.). New York: Pearson.
2. Ohanian, H. C. & Markert, J. T. (2006). *Physics for engineers and scientists* (3^{rd} ed.). New York: W. W. Norton.
3. Serway, R. A. & Jewelt, J. W. (2014). *Physics for scientist and engineers* (9^{th} ed.). New York: Brooks/Cole.

MATH-5121 **Techniques of Integration** **3(3+0)**

This is the second course of the basic sequence Calculus serving as the foundation of advanced subjects in all areas of mathematics. The sequence, equally, emphasizes basic concepts and skills needed for mathematical manipulation. we use the tangent and velocity problems to introduce the derivative, which isthe central idea in differential calculus. In much the same way, this course starts with the area and distance problems and uses them to formulate the idea of a definite integral, which is the basic concept of integral calculus. We use the integral to solve problems concerning volumes, lengths of curves, population predictions, cardiac output, forces on a dam, work, consumer surplus, and baseball, among many others. There is a connection between integral calculus and differential calculus. The Fundamental Theorem of Calculus relates the integral to the derivative, and we see in this course that it greatly simplifies the solution of many problems.Some of the applications of the definite integral are by using it to compute areas between curves, volumes of solids, and the work done by a varying force. The common theme is the following general method, which is like the one we used to find areas under curves. We evaluate the integral using the numerical methods where the antiderivative is not possible. We develop techniques for using these basic integration formulas to obtain in definite integrals of more complicated functions. We learn the most important method of integration, the substitution rule and integration by parts. Then we learn methods that are special to classes of functions, such as trigonometric functions and rational functions. Integration is not as straightforward as differentiation; there are no rules that absolutely guarantee obtaining an indefinite integral of a function. Therefore, we discuss a strategy for integration. We explore some of the many other geometric applications of integration the length of a curve, the area of a surface as well as quantities of interest in physics, engineering, biology, economics, and statistics. For instance, we investigate the center of gravity of a plate, the force exerted by water pressure on a dam, the flow of blood from the human heart, and the average time spent on hold during a customer support telephone call.

Contents

1. Integrals: area between curves
2. Volumes, work, average value of a function
3. Techniques of integration: integration by parts
4. Trigonometric integrals, trigonometric substitution
5. Integration of rational functions by partial fraction
6. Approximate integration, improper integration
7. Further applications of integration: arc length
8. Area of a surface of revolution, applications

Recommended Texts

1. Stewart, J. (2016). *Calculus early transcendental (8th* ed.). New York: Brooks/Cole.
2. Anton, H., Bivens, I. C. & Davis, S. (2016). *Calculus* (11th ed.). New Jersey: Wiley.

Suggested Readings

1. Thomas, G. B. (2015). *Calculus (*12th ed.). India: Pearson.
2. Goldstein, L. J., Lay, D. C., Schneider, D. I. & Asmar, N. H. (2017). *Calculus & its applications* (14th ed.). London: Pearson.

URCE-5102 Language Comprehension & Presentation Skills 3(3+0)

The course aims at developing linguistic competence by focusing on basic language skills in integration to make the use of language in context. It also aims at developing students' skills in reading and reading comprehension of written texts in various contexts. The course also provides assistance in developing students' vocabulary building skills as well as their critical thinking skills. The contents of the course are designed on the basis of these language skills: listening skills, pronunciation skills, comprehension skills and presentation skills. The course provides practice in accurate pronunciation, stress and intonation patterns and critical listening skills for different contexts. The students require a grasp of English language to comprehend texts as organic whole, to interact with reasonable ease in structured situations, and to comprehend and construct academic discourse. The course objectives are to enhance students' language skill management capacity, to comprehend text(s) in context, to respond to language in context, and to write structured response(s).

Contents

1. Listening skills
2. Listening to isolated sentences and speech extracts
3. Managing listening and overcoming barriers to listening
4. Expressing opinions (debating current events) and oral synthesis of thoughts and ideas
5. Pronunciation skills
6. Recognizing phonemes, phonemic symbols and syllables, pronouncing words correctly
7. Understanding and practicing stress patterns and intonation patterns in simple sentences
8. Comprehension skills
9. Reading strategies, summarizing, sequencing, inferencing, comparing and contrasting
10. Drawing conclusions, self-questioning, problem-solving, relating background knowledge
11. Distinguishing between fact and opinion, finding the main idea, and supporting details
12. Text organizational patterns, investigating implied ideas, purpose and tone of the text
13. Critical reading, SQ3R method
14. Presentation skills, features of good presentations, different types of presentations
15. Different patterns of introducing a presentation, organizing arguments in a presentation
16. Tactics of maintaining interest of the audience, dealing with the questions of audience
17. Concluding a presentation, giving suggestions and recommendations

Recommended Texts

1. Mikulecky, B. S. & Jeffries, L. (2007). *Advanced reading power: Extensive reading, vocabulary building, comprehension skills, reading faster*. New York: Pearson.
2. Helgesen, M. & Brown, S. (2004). *Active listening: Building skills for understanding*. Cambridge: Cambridge University Press.

Suggested Readings

1. Roach, C. A. & Wyatt, N. (1988). *Successful listening*. New York: Harper & Row.
2. Horowitz, R. & Samuels, S. J. (1987). *Comprehending oral and written language*. San Diego: Academic Press.

URCI-5105 **Islamic Studies** **2(2+0)**

Islamic Studies engages in the study of Islam as a textual tradition inscribed in the fundamental sources of Islam; Quran and Hadith, history and particular cultural contexts. The area seeks to provide an introduction to and a specialization in Islam through a large variety of expressions (literary, poetic, social, and political) and through a variety of methods (literary criticism, hermeneutics, history, sociology, and anthropology). It offers opportunities to get fully introductory foundational bases of Islam in fields that include Quranic studies, Hadith and Seerah of Prophet Muhammad (PBUH), Islamic philosophy, and Islamic law, culture and theology through the textual study of Quran and Sunnah.. Islamic Studies is the academic study of Islam and Islamic culture. It majorly comprises of the importance of life and that after death. It is one of the best systems of education, which makes an ethical groomed person with the qualities which he/she should have as a human being. The basic sources of the Islamic Studies are the Holy Quran and Sunnah or Hadith of the Holy Prophet Muhammadﷺ. The learning of the Quran and Sunnah guides the Muslims to live peacefully.

Contents

1. Study of the Quran (introduction to the Quran, selected verses from *surah al-baqarah, al-furqan, al-ahzab, al-mu'minoon, al-an'am, al-hujurat, al-saff*)
2. Study of the hadith (introduction to hadith literature, selected ahadith (text and translation)
3. Introduction to Quranic studies
4. Basic concepts of Quran
5. History of Quran
6. Basic concepts of hadith
7. History of hadith
8. Kinds of hadith
9. Uloom –ul-hadith
10. Sunnah & hadith
11. Seerat ul-nabi (pbuh), necessity and importance of seerat, role of seerah in the development of personality, pact of madinah, khutbah hajjat al-wada' and ethical teachings of prophet (pbuh).
12. Legal position of sunnah
13. Islamic culture & civilization
14. Characteristics of islamic culture & civilization
15. Historical development of islamic culture & civilization
16. Comparative religions and contemporary issues
17. Impact of islamic civilization

Recommended Texts

1. Hassan, A. (1990). *Principles of Islamic jurisprudence*. New Delhi: Adam Publishers.
2. Zia-ul-Haq, M. (2001). *Introduction to al-Sharia al-Islamia*. Lahore: Aziz Publication.

Suggested Readings

1. Hameedullah, M. (1957). *Introduction to Islam*. Lahore: Sh M Ashraf Publisher.
2. Hameedullah, M. (1980). *Emergence of Islam*. New Delhi: Adam Publishers.
3. Hameedullah, M. (1942). *Muslim conduct of state.* Lahore: Sh M Ashraf Publisher.

PHYS-5105 **Electricity and Magnetism-II** **3(3+0)**

Electricity & Magnetism-II is the continuation of Electricity & Magnetism-I. A static charge creates an electric field which we discuss in details in electricity & Magnetism-I, while a moving charge creates a magnetic field upon which is the point of discussion in this course. The aim of this course is to familiarize students with the sources of magnetic field and law through which we can calculate the magnetic field created by some specific current distribution like linear surface and volume current distributions. This course also deals with the applications of magnetic fields and currents in developing of D.C motors and D.C generators. Final part of this course concerns with the application of Electricity & Magnetism-I and II in electromagnetic waves (Radio T.V and Mobile signals) and their mathematical description.

Contents

1. Magnetic field
2. Magnetic forces on a single point charge/current carrying conductor
3. Torque on a current carrying loop and magnetic dipole
4. Biot & savart law and its analytical treatment and application
5. Amper's law and its applications
6. Electromagnetic induction and its laws
7. Inductance. Inductance for various configurations
8. Lr circuits. growth and decay of current in rl circuits
9. Electromagnetic oscillation (qualitative and quantitative analysis using differential equations)
10. Forced electromagnetic oscillations
11. Resonance
12. Alternating current circuits
13. Single loop rlc circuits (series and parallel)
14. Power in ac circuits and phase angles
15. Maxwell's equations (integral/differential forms)
16. Electromagnetic waves
17. Pointing vector
18. Magnetic properties of materials

Recommended Texts

1. Halliday, D., Resnick, R. & Walker, J. (2014). *Fundamentals of physics* (10th ed.). New York: Wiley.
2. Halliday, D., Resnick, R. & Krane, K. S. (2003). *Physics* (5th ed.). New York: Wiley.

Suggested Readings

1. Young, H. D., Freedman, R. A. & Ford, A. L. (2019). *University physics* (15th ed.). New York: Pearson.
2. Ohanian, H. C. & Markert, J. T. (2006). *Physics for engineers and scientists* (3rd ed.). New York: W. W. Norton.
3. Serway, R. A. & Jewelt, J. W. (2014). *Physics for scientist and engineers* (9th ed.). New York: Brooks/Cole.

PHYS-5106 Fundamentals of Quantum Mechanics 3(3+0)

Quantum mechanics is a physical science dealing with the behavior of matter and energy on the scale of atoms and subatomic particles / waves. It also forms the basis for the contemporary understanding of how very large objects such as stars and galaxies, and cosmological events such as the Big Bang, can be analyzed and explained. Quantum mechanics is the foundation of several related disciplines including nanotechnology, condensed matter physics, quantum chemistry, structural biology, particle physics, and electronics. Quantum mechanics is important because it plays a fundamental role in explaining how the world works. A physicist often says quantum mechanics governs the behavior of microscopic systems when in fact it governs the behavior of all physical systems, regardless of their size.

Contents

1. Particle-like properties of electromagnetic radiations
2. Black body radiation
3. Plank's radiation law and quantum of energy
4. Derivation of stefan's law and wien's displacement law from planck's radiation law
5. Quantization of energy, light quantization and photoelectric effect
6. The compton effect. wave-like properties of particles
7. Wave nature of matter and de-broglie hypothesis and its experimental verification
8. Wave packet and its localizations in space and time
9. Heisenberg uncertainty principle and its applications, bohr model of the atom: hydrogen spectrum
10. Bohr theory of atomic structure and hydrogen atom, bohr correspondence principle
11. Experimental evidence for quantization and determination of critical potential (frank-hertz exp)
12. Deficiencies of the bohr model characteristics of vector atomic model (space quantization)
13. Angular momenta and magnetic momenta), orbital angular momentum
14. Quantum mechanics: quantum mechanics and its postulates
15. Quantum operators and their properties, eigen value and eigen functions
16. Schrödinger wave equation (time dependent and time independent)
17. Application of time independent schrödinger wave equation
18. Probability density using the wave function of the state

Recommended Texts

1. Halliday, D., Resnick, R. & Krane, K.. (2008). *Fundamentals of physics* (8th ed.). New Jersey: Wiley.
2. Halliday, D., Resnick, R. & Walker, J. (2014). *Fundamental of physics* (10th ed.). New Jersey: Wiley.

Suggested Readings

1. Raymond A. & Vahe, P. (2014). *Physics for scientists and engineers with modern physics* (9th ed.). London: Pearson New International.
2. Beiser, A. (2003). *Concepts of modern physics* (6th ed.). New York: McGraw Hill.
3. Young, H. D., Freedman, R. A. & Ford, A. L. (2019). *University physics* (15th ed.). New York: Pearson.

PHYS-5107 Physics Lab-I 3(0+3)

The main emphasizes of this course is on graphical analysis, error calculation, and on system of S.I. units in the beginning of session. The purpose of this course is to prepare students with the latest development in this course and its associated technologies. Moreover, it aims at helping the students to design and develop a strong background in the fundamentals of physics such as mechanics, optics, magnetism and electricity, modern physics and electronics. We wish to prepare our students to conduct independent scientific and analytical investigation in the changing discipline and to enhance their expertise in setting up experiments, collecting and analyzing data.Further, students are also encouraged to share their knowledge and results for their advanced experimental training. Another purpose of this home-grown laboratory for basic experimental training is to enhance research driven culture among the students. It helps students to develop critical and scientific thinking skills needed for the understanding of fundamental concepts in physics.

Contents

1. Modulus of rigidity by static and dynamic method (maxwell's needle, barton's apparatus)
2. Surface tension of water by capillary tube method
3. To determine the value of "g" by compound pendulum/kater's pendulum
4. To determine horizontal/vertical distance by sextant
5. To study the laws of vibration of stretched string using sonometer
6. To determine the stopping potential by photocell
7. Measurement of resistance using a neon flash bulb and condenser
8. Conversion of a galvanometer into voltmeter
9. Conversion of a galvanometer into an ammeter

Recommended Texts

1. Melissinos, A. C. & Napolitano, J. (2003). *Experiments in modern physics.* New York: Gulf Professional Publishing.
2. Shamos, M. H. (2012). *Great experiments in physics: first hand accounts from Galileo to Einstein*. New York: Courier Corporation.

Suggested Readings

1. Mark, H. & Olsono, H. T. (2004). *Experiments in modern physics*. New York: McGraw-Hill
2. Young, H. D., Freedman, R. A. & Ford, A. L. (2019). *University physics* (15th ed.). New York: Pearson.
3. Musaddiq, M. H. (2008). *Experimental physics*. Lahore: Allied Book Center.
4. Serway, R. A. & Jewelt, J. W. (2014). *Physics for scientist and engineers* (9th ed.). New York: Brooks/Cole.

MATH-5122 **Calculus** **3(3+0)**

This is the third course of the basic calculus, consists of more topics of applicable mathematics. In previous courses, plane curves are described by giving a relation between x and y that defines y implicitly as a function. In this course, we discuss two new methods for describing curves. Some curves, such as the cycloid, are best handled when both x and y are given in terms of athird variable t called a parameter. Other curves, such as the cardioids, have their most convenient description when we use a new coordinate system, called the polar coordinate system. A coordinate system represents a point in the plane by an ordered pair of numbers called coordinates. Usually we use Cartesian coordinates, which are directed distances from two perpendicular axes. Here we describe a coordinate system introduced by Newton, called the polar coordinate system, which is more convenient for many purposes.The formulae of cartesian plane are all transformed in both parametric and polar forms. We also study geometric definitions of parabolas, ellipses, and hyperbolas and derive their standard equations. These curves are called *conic sections*, or *conics*, and model the paths travelled by planets, satellites, and other bodies whose motions are driven by inverse square forces. We see that once the path of a moving body is known to be a conic, we immediately have information about the body's velocity and the force that drives it. Planetary motion is best described with the help of polar coordinates, so we also investigate curves, derivatives, and integrals in this new coordinate system. Infinite sequences and series are introduced briefly. Their importance in calculus stems from Newton's idea of representing functions as sums of infinite series. For instance, in finding areas he often integrated a function by first expressing it as a series and then integrating each term of the series. We pursue his idea to integrate such functions which don't have anti derivatives.

Contents

1. Parametric equations: curves defined by parametric equations
2. Calculus with parametric curves, polar coordinates: introduction, areas and lengths in polar coordinates, conic sections, conic sections in polar coordinates
3. Infinite sequence and series: sequences, series
4. The integral test and estimates of sums, the comparison tests, alternating series
5. Absolute convergence and the ratio and root test
6. Strategy for testing series, power series, functions as power series, Taylor and maclaurin series

Recommended Texts

1. Thomas, G. B., Weir, M. D., Hass, J. & Giordano, F. R. (2005). *Thomas' calculus* (11th ed.). Boston: Addison Wesley.
2. Stewart, J. (2015). *Calculus* (8th ed.). Boston: Cengage Learning.

Suggested Readings

1. Anton, H., Bivens I. C. & Davis, S. (2016). *Calculus* (11th ed.). New Jersey: Wiley.
2. Goldstein, L. J., Lay, D. C., Schneider, D. I. & Asmar, N. H. (2017). *Calculus & its applications* (14th ed.). London: Pearson.
3. Hallett, D. H. (2017). *Calculus single and multivariable* (7th ed.). New Jersey: John Wiley & Sons.

MATH-5123 Ordinary Differentials Equations 3(3+0)

This course introduces the theory, solution, & application of ordinary differential equations. Topics discussed in the course include methods of solving first-order differential equations, existence & uniqueness theorems, second-order linear equations, power series solutions, higher-order linear equations, systems of equations, non-linear equations, Sturm-Liouville theory, & applications. The relationship between differential equations & linear algebra is emphasized in this course. An introduction to numerical solutions is also provided. Applications of differential equations in physics, engineering, biology, & economics are presented. The goal of this course is to provide the student with an underst&ing of the solutions & applications of ordinary differential equations. The course serves as an introduction to both nonlinear differential equations & provides a prerequisite for further study in those areas.

Contents

1. Introduction to differential equations: preliminaries and classification of differential equations, verification of solution, existence of unique solutions, introduction to initial value problems, differential equations as mathematical models
2. First order ordinary differential equations: basic concepts, formation and solution of differential equations, separable equations, linear equations, integrating factors, exact equations
3. Solution of some nonlinear first order des by substitution, homogeneous equations, bernoulli equation, ricaati's equation and clairaut equation
4. Modeling with first-order odes: linear models, nonlinear models
5. Higher order differential equations: initial value and boundary value problems, homogeneous and nonhomogeneous linear des and their solutions, linear dependenceand independence, wronskian, reduction of order, homogeneous equations with constant coefficients
6. Nonhomogeneous equations, undetermined coefficients method, superposition principle, annihilator approach, variation of parameters, cauchy-euler equation, solving system of linear des by elimination, solution of nonlinear des
7. Series solutions: power series, ordinary and singular points, existence of power series solutions, solutions about singular points, types of singular points, fresenius theorem, existence of fresenius series solutions, special functions, the bessel, modified bessel, legendre and hermite equations and their solutions, sturm-liouville problems: introduction to eigen value problem, adjoint and self adjointoperators

Recommended Texts

1. Boyce, W. E. & Diprima, R. C. (2013). *Elementary differential equations and boundary value problems* (7th ed.). New Jersey: John Wiley & Sons.

Suggested Readings

1. Zill, D. G. & Michael, R. (1997). *Differential equations with boundary-value problems* (5th ed.). New York: Brooks/Cole.
2. Arnold, V. I. (1991). *Ordinary differential equations.* Berlin: Springer.

URCE-5103 **Academic Writing** **3(3+0)**

Academic writing is a formal, structured and sophisticated writing to fulfill the requirements for a particular field of study. The course aims at providing understanding of writer's goal of writing (i.e. clear, organized and effective content) and to use that understanding and awareness for academic reading and writing. The objectives of the course are to make the students acquire and master the academic writing skills. The course would enable the students to develop argumentative writing techniques. The students would be able to the content logically to add specific details on the topics such as facts, examples and statistical or numerical values. The course will also provide insight to convey the knowledge and ideas in objective and persuasive manner. Furthermore, the course will also enhance the students' understanding of ethical considerations in writing academic assignments and topics including citation, plagiarism, formatting and referencing the sources as well as the technical aspects involved in referencing.

Contents

1. Academic vocabulary
2. Quoting, summarizing and paraphrasing texts
3. Process of academic writing
4. Developing argument
5. Rhetoric: persuasion and identification
6. Elements of rhetoric: text, author, audience, purposes, setting
7. Sentence structure: accuracy, variation, appropriateness, and conciseness
8. Appropriate use of active and passive voice
9. Paragraph and essay writing
10. Organization and structure of paragraph and essay
11. Logical reasoning
12. Transitional devices (word, phrase and expressions)
13. Development of ideas in writing
14. Styles of documentation (MLA and APA)
15. In-text citations
16. Plagiarism and strategies for avoiding it

Recommended Texts

1. Swales, J. M., & Feak, C. B. (2012). *Academic writing for graduate students: essential tasks and skills* (3rd ed.). Ann Arbor: The University of Michigan Press.
2. Bailey, S. (2011). *Academic writing: a handbook for international students* (3rd ed.). New York: Routledge.

Suggested Readings

1. Craswell, G. (2004). *Writing for academic success*. London: SAGE.
2. Johnson-Sheehan, R. (2019). *Writing today*. Don Mills: Pearson.
3. Silvia, P. J. (2019). *How to write a lot: A practical guide to productive academic writing*. Washington: American Psychological Association.

PHYS-5108 Basics of Electronics and Nuclear Physics 3(3+0)

Using electronics today is so much part of our daily lives we hardly think of the way the world would be without electronics. These are products ranging from automotive engines to automated equipment in production settings. This course helps the students to develop understanding of the working principles and operations of Electronic device. Nuclear Physics deals with study of the structure of matter at the atomic level. It also deals with the study of interactions of the atom molecules and the building blocks. The applications of the subject are nuclear medicine, ion implantation in material engineering, magnetic resonance imaging, and radiocarbon dating in geology and archaeology and much more**.**

Contents

1. Basic electronics: energy bands in solids
2. P-type and n-type semiconductor materials
3. P-n junction (diode structure)
4. Characteristics and application as rectifiers
5. Transistor (basic structure and operation), characteristics of transistors
6. Load line of a transistor
7. Applications of a transistor
8. Logic gates and their basic applications
9. Nuclear structure and the basic properties of the nucleus (nuclear size, binding energy, angular momentum of the nucleus, magnetic moment and parity)
10. Meson theory of nuclear force
11. Radioactivity and laws of radioactive decay
12. Conservation laws in radioactive decays
13. Radioactive isotopes and carbon dating
14. Nuclear reactions: types of nuclear reactions and their q-values
15. The compound nucleus
16. Nuclear fission and fusion
17. Applications of nuclear physics

Recommended Texts

1. Boylestad, R. & Nashelsky, L. (2002). *Electronic devices and circuit theory*. New Jersy: Pearson Prentice Hall.
2. Floyd, T. L. (2007). *Principles of electric circuits*. New Jersy: Pearson Prentice Hall.

Suggested Readings

1. Halliday, D., Resnick, R. & Walker, J. (2014). *Fundamental of physics* (10th ed.). New York: Wiely.
2. Young, H. D., Freedman, R. A. & Ford, A. L. (2019). *University physics* (15th ed.). New York: Pearson.
3. Beiser, A. (2003). *Concepts of modern physics* (6thed.). New York: McGraw-Hill Education.
4. Grob, B. (2003). *Basic electronics*. New York: McGraw-Hill Education.

PHYS-5109 **Theory of Thermodynamics** **3(3+0)**

The course titled Theory of Thermodynamics is intended for students enrolled for B.S Degree in Physics. Thermodynamics literally means heat in motion. It is the branch of physics which deals with transformation of heat energy in to mechanical energy and vice versa. It describes processes that involve changes in temperature, transformation of energy, relationships between heat and work. Thermodynamics is a science and more importantly an engineering tool, that is necessary for describing the performance of propulsion systems, power generation systems, refrigerators, fluid flow, combustion and many other systems like these. o get a deeper inside and understanding in to the laws of thermodynamics, the molecular concept of matter can be incorporated into the study of thermodynamics by means of statistical mechanics. Objectives of this course are to enable students that they can understand the origin of heat and temperature, the basic laws of thermodynamics, the applications of these laws for controlling the heat phenomena.

Contents

1. Kinetic theory of gases, derivation of fundamental equation of kinetic theory of gases
2. Maxwell distribution of molecular speeds and energies, modification of kinetic theory for real gas, the van der waals equation, zeroth law of thermodynamics and thermal equilibrium
3. Definition and formulation of the first law of thermodynamics, calculation of work done
4. Consequences of the first law of thermodynamics, definition & measurement of enthalpy
5. The joule-thomson experiment, carnot cycle and efficiency measurements
6. Second law of thermodynamics and the concept of entropy, entropy and entropy measurements for reversible and irreversible process
7. Combined first and second law of thermodynamics, entropy changes in the ideal gases
8. The third law of thermodynamics and its uses, definition & mathematical expressions of free energy
9. Helmholtz energy and gibbs energy, the maxwell relationship
10. Transfer of heat, distribution and mean values, mean free path and microscopic calculations of mean free path
11. Brownian motion

Recommended Texts

1. Halliday, D., Resnick, R. & Krane, K. S. (2016). *Physics* (5th ed.). New York: Wiley.
2. Young, H. D., Freedman R. A., Ford, A. L., Seers, F. W. & Zemansky, P. (2008). *University physics* (13th ed.). San Francisco: Addison Wesley.

Suggested Readings

1. Serway, R. A. & Jewelt, J. W.(2019). *Physics for scientist and engineers* (10th ed). New York: Cengage Learning.
2. Halliday, D., Resnick, R. & Walker, J. (2014). *Fundamental of physics* (10th ed.). New York: Wiley.
3. Garg, S. C., Bansal, R.M. & Ghosh, C.K. (2012). *Thermal physics* (2nd ed.). New Delhi: McGraw Hill Education.

PHYS-5110 Physics Lab- II 3(0+3)

Physics is an experimental science. The theoretical concepts and relationships introduced in the lecture part of this lab course describe the general behavior of the experiments. This lab helps the students in improvising their approach towards the subject. This physics lab aids a student in establishing the relevance of the theory. It brings clarity in the mind of the students regarding the basic concept of the subject. The main objective of this lab is to experimentally observe certain physical phenomena. This course also provides the students with a broad understanding of the concepts involved in the experiments. Experiments carried out in this lab work helps students in learning how to be patient and careful while taking observation and hitherto. A student performing this lab will understand ionization potential, semiconductor diodes, resonance frequencies, different logic gates and the phenomena of rectification. In order to enhance scientific and critical thinking for the understanding of basic concepts in this course, they are encouraged to share their knowledge and results with their teachers.

Contents

1. Resonance frequency of an acceptor circuit
2. Resonance frequency of rejecter circuit
3. Determination of ionization potential of mercury
4. Characteristics of semiconductor diode (compare si with ge diode)
5. Setting up half wave and full wave rectifier and study various factors
6. To set up and study various logic gates using diodes and to develop their truth tables
7. To set up a single stage amplifier and study its voltage gain
8. Measurement of low resistance coil by using carry foster bridge

Recommended Texts

1. Melissinos, A. C. & Napolitano, J. (2003). *Experiments in modern physics.* New York: Gulf Professional Publishing.
2. Shamos, M. H. (2012). *Great experiments in physics: first hand accounts from Galileo to Einstein*. New York: Courier Corporation.

Suggested Readings

1. Mark, H. & Olsono, H. T. (2004). *Experiments in modern physics*. New York: McGraw-Hill
2. Young, H. D., Freedman, R. A. & Ford, A. L. (2019). *University physics* (15th ed.). New York: Pearson.
3. Musaddiq, M. H. (2008). *Experimental physics*. Lahore: Allied Book Center.
4. Arora, C.L. (2010). *B.Sc practical physics.* New Delhi: Chand & Company.
5. Singh, H. & Hemne, P.S. (2000). *B.Sc practical physics.* New Delhi: Chand & Company.

MATH-5124 **Vectors and Tensors Analysis** **3(3+0)**

In this course, we will study the most fundamental knowledge for understanding vectors and tensors were taught in the traditional way. Prior to our applying vector and tensor analysis to our research area of modern continuum mechanics, vector and tensor analysis provides a kind of bridge between elementary aspects of linear algebra, geometry, and analysis.Vector analysis, is concerned with differentiation and integration of vector fields, primarily in 3-dimensional Euclidean space and then in the broader sense as multivariable calculus, which includes vector calculus as well as partial differentiation and multiple integration. Vectors play an important role in differential geometry and in the study of partial differential equations. It is used extensively in physics and engineering, especially in the description of electromagnetic fields, gravitational fields and fluid flow. Tensors are important in physics because they provide a concise mathematical framework for formulating and solving physics problems in areas such as mechanics (stress, elasticity, fluid mechanics, moment of inertia), electrodynamics (electromagnetic tensor, Maxwell tensor, permittivity, magnetic susceptibility), or general relativity (stress–energy tensor, curvature tensor) and others. In applications, it is common to study situations in which a different tensor can occur at each point of an object; for example, the stress within an object may vary from one location to another. This leads to the concept of a tensor field. In some areas, tensor fields are so ubiquitous that they are often simply called "tensors".

Contents

1. Vector analysis: gradient
2. Divergence and curl of point functions
3. Expansion formulae
4. Curvilinear coordinates, line, surface and volume integrals
5. Gauss’s, green’s and stoke’s theorems
6. Proper and improper transformation
7. Cartesian tensors: summation convention
8. Transformation equations
9. Orthogonally conditions
10. Kronecker tensor and levi-civita tensor
11. Tensors of different rank
12. Inner and outer products
13. Contraction
14. Quotient theorems
15. Symmetric and anti-symmetric tensors
16. Application to vector analysis

Recommended Texts

1. Spiegel, E.C. (2016). *Vector and an introduction to tensor analysis. New York:* McGraw Hill.

Suggested Readings

1. Young, E.C. (1993). *Vector and tensor analysis*. New York: Marcel Dekker.
2. Borisenko, A. I. & Tarapov, I. E. (1979). *Vector and tensor analysis with applications*. New York: Dover.

MATH-5125 **Linear Algebra** **3(3+0)**

This course aims to provide a first approach to the subject of linear algebra, which is one of the basic pillars of modern mathematical physics. The aim is to present the fundamentals of linear algebra in the clearest possible way; sound pedagogy is the main consideration. Although calculus is not a prerequisite, but the knowledge of calculus is quite useful to boost the learning outcomes of the subject. We study linear transformations from a general vector space to a general vector space. The results we obtain here have important applications in physics, engineering, and various branches of sciences. We interpret an extension of the diagonalization theory for symmetric matrices to general matrices. The results developed in this way have applications to compression, storage, and transmission of digitized information and form the basis for many of the best computational algorithms that are currently available for solving linear systems. Efficient transmission and storage of large quantities of digital data has become a major problem in our technological world. We discuss the role that singular value decomposition plays in compressing digital data so that it can be transmitted more rapidly and stored in less space.A static structure such as a bridge has loads which must be calculated at various points. These are also vectors, giving the direction and magnitude of the force at those isolated points. In the theory of electromagnetism, Maxwell's equations deal with vector fields in 3-dimensional space which can change with time.

Contents

1. Subspaces, bases, dimension of a vector space
2. Quotient space, change of bases
3. Linear transformation and matrices
4. Inner product spaces and orthogonality, orthogonal subspaces
5. Rank and nullity of linear transformation
6. Eigen values and eigen vectors
7. Characteristic equation, similar matrices
8. Diagonalization of matrices
9. Orthogonal and orthonormal set
10. Gramm schmidt process of orthogonalizations
11. Characteristic equation, dual spaces

Recommended Texts

1. Anton, H. & Borres, C. (2010). *Elementary linear algebra* (10th ed.). New York: John Wiley & Sons.
2. Anton, H. & Rorres, C. (2010). *Elementary linear algebra: applications version* (10th ed.). New York: John Wiley and sons.

Suggested Readings

1. Hussain, K. (2007). *Linear algebra (*1st ed.). Lahore: Karwan Book Hous.
2. Friedberg, S. & Insel, A. (2003). *Linear algebra* (4th ed.). London: Pearson Education.
3. Grossman, S. I. (2004). *Elementary linear algebra* (5th ed.). New York: Cengage Learning.

STAT-5125 **Theory of Error Analysis** **3(3+0)**

This course is an introductory course designed for under-graduate level. Statistical analysis is a basic requirement in order to analyze the phenomenon related to all sectors. This course aims to produce skills related to descriptive as well as inferential statistical analysis of the theory of error analysis. This also deals with correlation and fitting of least square methods of error propagation. Objectives of this course are to provide the student a comprehensive introduction to error analysis and identification of the types and pattern of error to establish error taxonomies. It will enable students for, identification of error, description of error, evaluation of error, collection of sample for learner language and also utilization of different distributions. Thus, at each point of space and time, two vectors are specified, giving the electrical and the magnetic fields at that point. Given two different frames of reference in the theory of relativity, the trans-formation of the distances and times from one to the other is given by a linear mapping of vector spaces.

Contents

1. Preliminary description of error analysis, how to report and use uncertainties, discrepancy, comparison of measured and accepted values, comparison of two measured numbers, checking relationships with a graph, significant figures and fractional uncertainties, multiplying two measured numbers
2. Propagation of uncertainties, the square-root rule, independent uncertainties in a sum, arbitrary functions of one variable, general formula for error propagation, statistical analysis of random uncertainties, random and systematic errors
3. The mean and standard deviation, standard deviation of the mean, probability concepts, probabilities in dice throwing
4. The normal distribution and its properties , binomial distribution and its properties, the poisson distribution and its properties, the chi-squared test for a distribution, degrees of freedom and reduced chi squared, probabilities for chi squared, limiting distributions, justification of the mean as best estimate, justification of addition in quadrature, , acceptability of a measured answer, rejection of data, chauvenet's criterion, weighted averages
5. Covariance and correlation, covariance in error propagation, coefficient of linear correlation, least-squares fitting, calculation of the constants a and в and their uncertainty, least-squares fits to other curves

Recommended Texts

1. Hughes, I. & Hase, T. (2010). *Measurements and their uncertainties: a practical guide to modern error analysis* (1st ed.). New York: Oxford University Press.
2. Bevington, P. (2003). *Data reduction and error analysis for physical science* (3rd ed.). New York: McGraw Hill.

Suggested Readings

1. Roe, B. P. (1992). *Probability and statistics in experimental physics*. New York: Springer.
2. Taylor, J. (1982). *An introduction to error analysis*. California: University Science Books.
3. Mueller-kirsten, H. J. (2009). *Basics of statistical physics: a bachelor degree introduction*. London: World Scientific Publishing Company.
4. James, F. (2006). *Statistical methods in experimental physics* (2nd ed.). New York: World Scientific Publishing Company.

PHYS-6111 **Methods of Mathematical Physics-I** **3(3+0)**

This course provides a wide range of analytical mathematical techniques essential to the solution of advanced problems in physics. The main objective is to have an in-depth understanding of the basics of complex analysis, residue theorem and its applications to integral solving techniques. This course enables the student to solve for orthogonal functions, Beta functions, Factorial functions, Gamma functions Digamma and Poly-gamma functions and to compute their integral transforms. It also enables the student to apply special functions, their kinds and recurrence relations used in physics problems and to solve the second order differential equations using the concept of Sturm-Liouville theory, Green's functions and eigen valued problems. Thus, at each point of space and time, two vectors are specified, giving the electrical and the magnetic fields at that point. Given two different frames of reference in the theory of relativity, the trans-formation of the distances and times from one to the other is given by a linear mapping of vector spaces.

Contents

1. Function of complex variables and basic review
2. Analytic functions, harmonic functions
3. Cauchy riemann equations
4. Differentiation and integration of complex variables
5. Sequence and series in complex numbers
6. Calculus of residues and its basic concept
7. Evaluation of different integral types in residues
8. The gamma function (definition and its properties)
9. Factorial notations
10. Digamma and poly-gamma functions
11. Beta functions and its mathematical notations
12. Incomplete beta functions
13. Stirling's series
14. Eigen functions and orthogonal functions
15. Strum-liouville theory

Recommended Texts

1. Arfken, G. B., Weber, H. J. & Harris, F. E. (2011). *Mathematical methods for physicists* (7th ed.). New York : Elsevier Science.
2. Kreyszig, E. (2011). *Advanced engineering mathematics* (10th ed.). New York: Wiley.

Suggested Readings

1. Spiegel, M. R., Lipschutz, S., Schiller, J. J. & Spellman, D. (2009). *Schaum's outline of complex variables* (2nd ed.). New York: McGraw Hill Professional.
2. Wong, C. W. (2013). *Introduction to mathematical physics* (2nd ed.). Oxford: Oxford University Press.
3. Kakani, S. L. & Hemrajani, C. (2010). *Mathematical physics* (2nd ed.). New Delhi: CBS Publishers.

PHYS-6112 **Classical Mechanics –I** **3(3+0)**

The fundamental goal of this course is to create understanding in students to classical mechanics and its applications. The focus in this course will be given to develop knowledge of the physical concepts and mathematical methods of classical mechanics to develop skills in formulating and solving physics problems. Students will learn the use of Newton's laws of motion, conservation theorems to solve advanced problems involving the dynamic motion of classical mechanical systems. The studies will be extended to oscillatory objects, gravitation and systems of particles. This course provides the up-to-date treatment of classical mechanical systems so that students face least difficulty in understanding the advance topics covered in classical Mechanics II course. Thus, at each point of space and time, two vectors are specified, giving the electrical and the magnetic fields at that point. Given two different frames of reference in the theory of relativity, the trans-formation of the distances and times from one to the other is given by a linear mapping of vector spaces.

Contents

1. Historical background of classical mechanics
2. Concept of scalars vectors and coordinates transformations
3. Properties of orthogonal matrix
4. Vector products and proof of various identities of vectors
5. Velocity and acceleration in various coordinates
6. Gauss's divergence theorem and stokes theorem
7. The newtonian formulation of mechanics and kinematics of particle motion
8. Force and types of force, problems about constant force acting upon the body and motion on inclined plane
9. Motion of the body in resistive medium solving the problem free falling object and motion of projectile and atwood's machine
10. Conservation theorems: linear momentum, angular momentum and conservation of energy equilibrium and its type
11. Motion in electromagnetic field, equilibrium and nature of equilibrium
12. Oscillatory motion, free oscillator in one and two dimension
13. Damped oscillator and its types, under-damped, critically damper and over damped oscillator
14. Forced oscillator

Recommended Texts

1. Thornton, S. T. & Marion, J. B. (2012). *Classical dynamics of particles and systems* (5^{th} ed.). New York: Thomson Brooks/Cole
2. Goldstein, H., Charles, P. P. & Safko J. L. (2001). *Classical mechanics* (3^{rd} ed). Massachusetts: Addison Wesley Reading.

Suggested Readings

1. Taylor, J. R. (2005). *Classical mechanics*. California: University Science Books.
2. Tom, W. B. K. (2005). *Classical dynamics* (5^{th} ed.). London: Imperial College Press.
3. Finn, J. M. (2010). *Classical dynamics.* Boston: Jones and Bartlett Publishers.

PHYS-6113 Electrodynamics-I 3(3+0)

This course is all about one of the four known forces (gravitational force, electromagnetic force, weak nuclear force and strong nuclear force) of nature – electromagnetic force. The course will cover a number of fundamental topics in electromagnetism, including a brief review of basic concepts, electrostatics in free space, Poisson's and Laplace's equations, solution of boundary-value problems, Method of Images, Multipole expansion and re-formulation of electrostatics inside matter. In addition to expanding the application of these concepts to more general problems, a significant part of the course will involve the development of expertise in more advanced mathematical techniques, including especially the always interesting Green's functions, Bessel's functions, Legendre's & associated Legendre's functions and spherical harmonics. Thus, at each point of space and time, two vectors are specified, giving the electrical and the magnetic fields at that point. Given two different frames of reference in the theory of relativity, the trans-formation of the distances and times from one to the other is given by a linear mapping of vector spaces.

Contents

1. Differential calculus: gradient; divergence; curl
2. Integral calculus: gradient theorem; green's theorem; stokes' theorem
3. Orthogonal coordinate systems: cartesian coordinates
4. Cylindrical coordinate; spherical coordinates
5. Electrostatics in free space: coulomb's law for electric force, electric field and electric potential due to a single point charge, discrete charge distribution and continuous charge distributions
6. Gauss's law; electrostatic boundary conditions
7. Electrostatic energy for discrete and continuous charge distributions; conductors
8. Capacitors: parallel-plate capacitor
9. Cylindrical capacitor; spherical capacitor
10. Boundary-value problems: solutions of laplace's equation in cartesian, cylindrical and spherical coordinates
11. Poisson's equation
12. Method of images; other image problems

Recommended Texts

1. Griffiths, D. J. (2007). *Introduction to electrodynamics* (4th ed.). New York: Prentice Hall.
2. Cheng, D. K. (2013). *Field and wave electromagnetics* (2nd ed.). New York: Pearson.

Suggested Readings

1. Vanderlinde, J. (2005). *Classical electromagnetic theory* (2nd ed.). New York: Springer.
2. Zahn, M. (2003). *Electromagnetic field theory: a problem solving approach* (1st ed.). Florida: Krieger Publishing Co.
3. Fleisch, D. (2008). *A student's guide to Maxwell's equations* (1st ed.). Cambridge: Cambridge University Press.

PHYS-6114 **Electronics** **3(3+0)**

Electronics is the application of devices controlling the flow of electrons. The nonlinear behavior of active components and their ability to control electron flows makes amplification of weak signals possible. Electronics is widely used in information processing, telecommunication, and signal processing. The ability of electronic devices to act as switches makes digital information processing possible. Interconnection technologies such as circuit boards, electronics packaging technology and other varied forms of communication infrastructure complete circuit functionality and transform the mixed components into a regular working. This course covers the basic concepts of electronics which helps students to learn and understand it clearly. Thus, at each point of space and time, two vectors are specified, giving the electrical and the magnetic fields at that point. Given two different frames of reference in the theory of relativity, the trans-formation of the distances and times from one to the other is given by a linear mapping of vector spaces.

Contents

1. Semiconductor diode and application, semiconductor diode, characteristics curves
2. Dc & ac resistance, diode equivalent circuit, series and parallel diode configuration with dc load
3. Rectification, half and full wave rectifier circuit with and without filter, zener diode, led
4. Bjt's: transistor and transistor operation, transistor configurations (cb, ce, cc)
5. Current amplification factors, load line and operating conditions
6. Dc biasing (voltage divider bias c-e amplifier), design of voltage divider bias c-e amplifier
7. Negative feedback amplifiers, general characteristics of negative feedback amplifiers
8. Classification of negative feedback amplifiers, voltage series feedback amplifier. Integrated amplifier: the differential amplifier (modes of operation, common mode rejection ratio)
9. Operational amplifier and its parameters, op-amp configuration with negative feedback, op-amp applications (voltage summing, voltage buffer, voltage comparators)
10. Op-amp as differentiator and integrator oscillators: oscillator principles and conditions for oscillation, oscillator with lc feedback circuits
11. Transistor rc phase shift oscillator, crystal oscillators, ujt relaxation oscillator, multi vibrators, schmitt trigger

Recommended Texts

1. Boylestad, R. & Nashelsky, L. (2002). *Electronic devices and circuit theory*. New Jersey: Pearson Prentice Hall.
2. Floyd, T. L. (2007). *Principles of electric circuits*. New Jersey: Pearson Prentice Hall.

Suggested Readings

1. Halliday, D., Resnick, R. & Walker, J. (2014). *Fundamental of physics* (10th ed.). New York: Wiely.
2. Young, H. D., Freedman, R. A. & Ford, A. L. (2019). *University physics* (15th ed.). New York: Pearson.
3. Beiser, A. (2003). *Concepts of modern physics* (6th ed.). New York: McGraw-Hill Education.

PHYS-6115 **Electronics Lab** **3(0+3)**

This course introduces the students to basic of electric circuits through a series of experiments. This includes the working principles of resistors, capacitors and inductors. Students learn different experimental techniques to determine the values of combination of different circuits. The course introduces students to the basic components of electronics: diodes, transistors, and operational amplifiers. It covers the basic operation and some common applications.This laboratory course will help the students in getting familiarized with basic electrical measurement techniques, enhancing ability to apply electrical theory to practical problems, practice in recording and reporting technical information, familiarization with electrical safety requirement and also verification of some basic electric circuit theorems.

Contents

1. To construct from discrete components or, and, not circuits and verify their truth tables
2. To construct from discrete components nand, nor, exclusive or circuits and verify their truth tables
3. Design a fixed and self-bias and voltage divider bias transistor
4. To construct a single stage ce transistor voltage amplifier and study gain, input impedance, output impedance, and half power points by sine/square wave testing and effect of bias on the output and measurement of distortion
5. To construct and study the wave forms at the base and collector of the transistors of a free running a multivibrators
6. To construct and study of the height, duration and time period of the output pulses in a monostable and bistabale multivibrators with reference to the input trigger
7. To study of rc integrators and differentiators
8. Design an inverting and non-investing d.c. Amplifier, measurement of parameters of a given ic operational amplifier
9. Design and study the application of operational amplifier (current to voltage converter, instrumentation amplifier, buffer, voltage clamp, integrator and differentiator. low and high pass filters and half-wave rectifier)
10. To construct a phase shift or wein bridge oscillator and measure its frequency by 741,555 timer

Recommended Texts

1. Robert, L. B. & Nashelsky, L. (2005). *Electronic devices and circuit theory* (9th ed.). New Jersey: Prentice Hall.
2. Higgins, R. J. (1974). *Experimental electronics* (4th ed.). New York: McGraw-Hill Education.

Suggested Readings

1. Mitchel, E. S. (2003). *Grob's basic electronics* (13th ed.). New York: McGraw-Hill Education.
2. Thomas, L. F. (1981). *Principles of electric circuits* (31st ed.). Boston: Charles E. Merrill Publishing Co.

PHYS-6116 Methods of Mathematical Physics-II 3(3+0)

This course provides a wide range of analytical mathematical techniques essential to the solution of advanced problems in physics. The main objective is to develop intuition towards formulating physical phenomena in mathematical language and gain an appreciation of the analytical methods that are most commonly used to solve problems in physics. This course has an in-depth understanding of the basics of Legendre functions, Hermite functions, Laguerre functions, Chebyshev functions and its applications to problem solving techniques. It enables the student to solve for Fourier series, Fourier integral and compute their Fourier transforms. It also enables the student to apply Laplace transform and inverse Laplace transform to solve the initial value problems.

Contents

1. Fourier series
2. Basic definition and properties of fourier series
3. Complex fourier
4. Gibbs phenomenon
5. Fourier integral
6. Fourier transforms
7. Discrete fourier transform
8. Legendre functions
9. Generating function
10. Recurrence relations
11. Orthogonality
12. Associated legendre functions
13. Legendre functions of second kind
14. Laguerre functions
15. Hermite functions
16. Laplace transforms
17. Basic concept of laplace transforms andinverse laplace transform
18. Laplace transforms of different functions
19. Transfer function, initial value problem solving method

Recommended Texts

1. Arfken, G. B., Weber, H. J. & Harris, F. E. (2011). *Mathematical methods for physicists* (7th ed.). New York : Elsevier Science.
2. Kreyszig, E. (2011). *Advanced engineering mathematics* (10th ed.). New York: Wiley.

Suggested Readings

1. Spiegel, M. R., Lipschutz, S., Schiller, J. J. & Spellman, D. (2009). *Schaum's outline of complex variables* (2nd ed.). New York: McGraw Hill Professional.
2. Wong, C. W. (2013). *Introduction to mathematical physics* (2nd ed.). Oxford: Oxford University Press.
3. Kakani, S. L. & Hemrajani, C. (2010). *Mathematical physics* (2nd ed.). New Delhi: CBS Publishers & Distributors.

PHYS-6117 **Classical Mechanics- II** **3(3+0)**

The aim of this course is to continue, merge and extend the studies of Classical Mechanics I PHYS-302 in previous semester. Its ideas also link with other courses like quantum mechanics and condensed matter. The fundamental goal of this course is to create understanding in students to classical mechanics and its applications. This course provides the students the up-to-date treatment of classical mechanical systems and serves as basics and pre-requisite of Quantum Mechanics so that students face least difficulty in entering from classical Physics to Quantum mechanics. The purpose of the course is to make the students capable in formulating and solving physics problems. Thus, at each point of space and time, two vectors are specified, giving the electrical and the magnetic fields at that point. Given two different frames of reference in the theory of relativity, the trans-formation of the distances and times from one to the other is given by a linear mapping of vector spaces.

Contents

1. Some methods in the calculus of variations
2. Euler's equation, "first and second form" of euler's equation
3. Kinematics of system of particles
4. Collision between particles, centre of mass and lab co-ordinate system, elastic collision in lab and cm coordinate system
5. Scattering by central force field
6. Rutherford's scattering formula
7. Rocket motion
8. Limitations of newtonian mechanics, generalized co-ordinates and constraints, virtual displacement and virtual work
9. D' alembert's principle
10. Lagrange 's equation of motion
11. Hamilton's principle and lagrange's equation
12. Hamiltonian of dynamical system
13. Hamilton's canonical equations
14. Poisson bracket and their properties
15. Central force motion

Recommended Texts

1. Thornton, S. T. & Marion, J. B. (2012). *Classical dynamics of particles and systems* (5^{th} ed.). New York: Thomson Brooks/Cole
2. Goldstein, H., Charles, P. P. & Safko J. L. (2001). *Classical mechanics.* (3^{rd} ed). Massachusetts: Addison Wesley Reading.

Suggested Readings

1. Taylor, J. R. (2005). *Classical mechanics*. California: University Science Books.
2. Tom W. B. K. (2005). *Classical dynamics* (5^{th} ed.). London: Imperial College Press.
3. Finn J. M. (2010). *Classical dynamics.* Boston: Jones and Bartlett Publishers.

PHYS-6118 **Electrodynamics-II** **3(3+0)**

This course is the second in a series on Electrodynamics beginning with Electrodynamics-I (PHYS-6113). The course will cover various topics in electromagnetism, including equation of continuity, magnetostatics in free space, re-formulation of magnetostatics inside matter, magnetic media, electrodynamics, Faraday's law of induction, Maxwell's equations in free space & inside matter and electromagnetic waves in free space & inside matter. The course will not only review the basic material, students learned in Electricity and Magnetism-II (PHYS-5105) but will go beyond in both contents as well as mathematical sophistication. A solid understanding of how to manipulate the complex mathematical equations will give the students a much stronger toolbox for confidence in analyzing a wider range of geometries and problems.

Contents

1. Electric currents: line currents, surface currents, volume currents, equation of continuity
2. Magnetostatics in free space: biot-savart law for magnetic force, magnetic field and magnetic vector potential due to line, surface and volume currents
3. Solutions of laplace's vector equation and poisson's vector equation
4. Ampere's law, magnetostatic boundary conditions
5. Magnetic field and magnetic vector potential of a magnetic dipole, multipole expansion of magnetic vector potential
6. Magnetostatics inside matter: magnetization; magnetic field and magnetic vector potential of a magnetized object, bound currents
7. Ampere's law inside matter; boundary conditions on magnetic displacement, paramagnetic, diamagnetic and ferromagnetic materials
8. Electrodynamics: ohm's law, electromotive force
9. Faraday's law
10. Lenz's law
11. Inductors, mutual and self inductance, energy stored in magnetic field
12. Maxwell's equations in free space for static and dynamic cases, displacement current
13. Maxwell's equations inside matter for static and dynamic cases, polarization current
14. Electromagnetic waves in free space
15. Electromagnetic waves inside matter

Recommended Texts

1. Griffiths, D. J. (2007). *Introduction to electrodynamics* (4th ed.). New York: Prentice Hall.
2. Cheng, D. K. (2013). *Field and wave electromagnetics* (2nd ed.). New York: Pearson.

Suggested Readings

1. Vanderlinde, J. (2005). *Classical electromagnetic theory* (2nd ed.). New York: Springer.
2. Zahn, M. (2003). *Electromagnetic field theory: a problem solving approach* (1st ed.). Florida: Krieger Publishing Co.
3. Fleisch, D. (2008). *A student's guide to Maxwell's equations* (1st ed.). Cambridge: Cambridge University Press.

PHYS-6119 **Quantum Mechanics-I** **3(3+0)**

Quantum mechanics is important because it plays a fundamental role in explaining how the world works. Physicists often say quantum mechanics governs the behavior of microscopic systems when in fact it governs the behavior of all physical systems, regardless of their size. Quantum mechanics tells us a lot about the structure of reality. In this course we review the fundamental ideas of quantum mechanics, introduce the path integral for a non-relativistic point particle, and use it to derive time-dependent perturbation theory and the Born series for non-relativistic scattering. The course concludes with an introduction to relativistic quantum mechanics and the ideas of quantum field theory. This course provides the students the up-to-date treatment of classical mechanical systems and serves as basics and pre-requisite of Quantum Mechanics so that students face least difficulty in entering from classical Physics to Quantum mechanics.

Contents

1. Review of concepts of classical mechanics
2. Historical review (experiments and theories)
3. Wave aspects of particles
4. Hilbert space and wave functions
5. Mathematical tools of quantum mechanics
6. The linear vector space, the hilbert space, dimensions and basis of a vector space
7. Square integrable wave functions, dirac notation and operators
8. Basic postulates of quantum mechanics
9. The state of a system and observables
10. Measurement in quantum mechanics
11. Time evolution of the system's state
12. Time evolution operator, stationary states
13. Time independent potentials, time evolution of expectation values
14. Symmetries and conservation laws
15. General properties of one dimensional schrödinger equation
16. Symmetric potentials and parity

Recommended Texts

1. Liboff, R. L. (2002). *Introductory quantum mechanics* (4th ed.). New York: Addison Wesley Publishing Company.
2. Zettili, N. (2009). *Quantum mechanics: concepts and applications* (2nd ed.). New York: Wiley.

Suggested Readings

1. Townsend, J. S. (2012). *A modern approach to quantum mechanics* (2nd ed.). New York: University Science Books.
2. Robinett, R. W. (2006). *Quantum mechanics, classical results, modern systems and visualized examples* (2nd ed.). Oxford: Oxford University Press.
3. Gasiorowicz, S. (2003). *Quantum physics* (3rd ed.). New York: Wiley.
4. Griffiths, D. J. (2018). *Introduction to quantum mechanics* (3rd ed.). Cambridge: Cambridge University Press.

PHYS-6120 Solid State Physics-I 3(3+0)

This course mainly provides an introduction to the theory of solid state materials with emphasis on crystalline materials. Their diverse interesting properties can comprehensively be illustrated using some fundamental concepts related to their internal geometries. This course includes a theoretical description of crystal structure and its different geometries, interatomic bonding, detailed investigation of theoretical and experiment concepts of x-ray diffraction, and involvement of lattice dynamics, which give birth to some successful theories of lattice heat capacity of solids based on the principles of classical and quantum physics. The course provides a basis for understanding the scientific literature on novel materials and to further studies in material science and nanotechnology. This course provides the students the up-to-date treatment of classical mechanical systems and serves as basics and pre-requisite of Quantum Mechanics so that students face least difficulty in entering from classical Physics to Quantum mechanics.

Contents

1. Crystal structure in 2D and 3D, fundamental types of lattices
2. Index system for crystal planes, simple crystal structures
3. X-ray diffraction, braggs law
4. Reciprocal lattice, diffraction of waves by crystals
5. Scattered wave amplitude
6. Brillouin zones
7. Crystal binding and elastic constants
8. Classification of solids, ionic crystals, covalent crystals, ionic radii, II-VI and III-V compounds
9. Molecular crystals, metals, cohesive energy
10. The lenard jones potential
11. Density, cohesive energy and bulk modulus of crystalline solids, the madelung constant
12. Vibration of crystals with monatomic and diatomic lattice
13. Quantization of elastic waves, normal vibration modes
14. Phonon, phonon momentum
15. Inelastic scattering by phonons, phonon heat capacity
16. lattice heat capacity, einstein and debye models
17. Sommerfeld model of free electron theory
18. Energy levels in one dimension
19. Free electron gas in three dimension
20. DC and ac electrical conductivity of metals

Recommended Texts

1. Kittle, C. (2005). *Introduction to solid state physics* (8th ed.). New Jersey: Wiley
2. Wahab, M. A. (2017). *Solid states physics: structure and properties of materials* (3rd ed.). Oxford: Alpha Science International.

Suggested Readings

1. Szwachi, N. G. & Szwacka, T. (2016). *Basic elements of crystallography* (2nd ed.). Singapore: Pan Stanford Publishing.
2. Simon, S. H. (2013). *The oxford solid state basics* (1st ed.). Oxford: Oxford University Press.

PHYS-6121 Modern Physics Lab 3(0+3)

20^{th} century seen new scientific theories with experimental developments known in language of physics as Modern Physics. This course is developed in order to familiarize the students with some of the theories of that era with experimental proofs and to develop a scientific behavior in experimental physics for research fields. These experiments deals with measurements of charge to mass ratio of an electron, particle and wave nature (wave-particle duality) of light, detection and measurements of radioactive radiation, measurement of speed of light, measurement of excitation potential of Mercury, measurement of wavelength of Sodium light, diffraction pattern and deviation of light when light changes its medium ,etc. This course provides the students the up-to-date treatment of classical mechanical systems and serves as basics and pre-requisite of Quantum Mechanics so that students face least difficulty in entering from classical Physics to Quantum mechanics.

Contents

1. To determine the Cauchy's constants using spectrometer
2. Measurement of wavelength of mercury light using Michelson interferometer
3. To determine the charge to mass ratio (e/m) of electron by fine beam tube method
4. Determination of speed of light using optical fiber
5. Characteristics of G. M tube, radiation detection, shielding and analysis
6. Radio frequency measurements (determination of dielectric constants of solids)
7. To study the characteristics of a Geiger-Muller counter and to examine the attenuations of beta particles in Al-and Pb foils
8. Measurement of the spectrum of gamma rays from a radioisotope, shielding and attenuation of gamma rays
9. The Frank-hertz experiment (measurement of excitation potential of Hg)
10. AC circuits and dielectric constants of water and ice
11. Radio frequency measurement, skin effect, etc
12. Experiments with transmission lines
13. Source strength of Co60 by gamma coincidence methods
14. To examine the stopping-power of various substances for thermal neutrons
15. Determination of the Rydberg constant from the spectrum of hydrogen
16. To study the Zeeman effect for a line in the spectrum of helium
17. Electron spin resonance (E.S.R.) by microwave absorption
18. The measurement of the Hall Effect in germanium and silicon

Recommended Texts

1. Mark, H. & Olsono, H.T. (2004). *Experiments in modern physics*. New York: McGraw-Hill
2. Melissinos, A.C. (2008). *Experiments in modern physics.* New York: Academic press.

Suggested Readings

1. Melissinos, A. C. & Napolitano, J. (2003). *Experiments in modern physics.* New York: Gulf Professional Publishing.
2. Shamos, M. H. (2012). *Great experiments in physics: first hand accounts from Galileo to Einstein.* New York: Courier Corporation.

PHYS-6122 Statistical Mechanics 3(3+0)

The course titled Statistical Mechanics is intended for students enrolled for B.S degree in Physics. The purpose of this course is to translate the microscopic world where the laws of nature are written to the everyday macroscopic world that we're familiar with. This will allow us to begin to address very basic questions about how matter behaves. Statistical Mechanics is a probabilistic approach to equilibrium properties of large numbers of degrees of freedom. This course aims to cover both classical and quantum statistical mechanics. It demonstrates the firm physical and statistical basis of thermodynamics by showing how the properties of macroscopic systems are direct consequences of the behaviors of their elementary constituents. We can apply statistical mechanics to solve for real systems (a system for many particles). This course will provide students a broader spectrum of skills as well as a better understanding of the physical bases. They will be able to apply the concepts learnt to everyday problems and systems.

Contents

1. Review of thermodynamics: mathematical formulation of first and second law of thermodynamics
2. Maxwell's relation, reduction of derivatives, general conditions of equilibrium
3. Partition function: partition function, relations of partition function with thermodynamical variables, examples (collection of simple harmonic oscillators, half spin paramagnet)
4. Basic principles of statistical mechanics: microscopic and macroscopic states, phase space, ensemles,liouvillie theorem
5. Formation of microcanonical, canonical and grand canonical partition function, maxwell distribution of molecular speed
6. Probability of the particle in quantum state, density of states in k-space,single particle density of states in energy
7. Maxwell-boltzman distribution function, validity of maxwell-boltzman statistics, evaluation of constants α and β, maxwell speed distribution function
8. Theory of ideal fermi system: fermi-dirac distribution function, examples of the fermi system (free electron theory of metals, electrons in stars, electrons in white dwarf stars)

Recommended Texts

1. Reif, F. (2009). *Fundamentals of statistical and thermal physics*. New York: McGraw Hill.
2. Garg, S. C., Bansal, R.M. & Ghosh, C.K. (2012). *Thermal physics* (2nd ed.). New Delhi: McGraw Hill.

Suggested Readings

1. Agarwal, B. K. & Melvin, E. (2012). *Statistical mechanics* (3rd ed.). New Delhi: New Age International.
2. Pathria, R. K. (2011). *Statistical mechanics*.UK: Elsevier Ltd.
3. Sinha, S. K. (2007). *Introduction to statistical mechanics*. Oxford: Alpha Science International.

PHYS-6123 **Atomic Physics** **3(3+0)**

Atomic physics (or atom physics) is a field of physics that involves investigation of the structures of atoms, their energy states, and their interactions with other particles and electromagnetic radiation. In this field of physics, atoms are studied as isolated systems made up of nuclei and electrons. Its primary concern is related to the arrangement of electrons around the nucleus and the processes by which these arrangements change. The aim of this course is to develop an understanding to the physics of atoms, atomic structure. Additionally it covers, the observed dependence of atomic spectral lines on externally applied electric and magnetic fields. This course provides the students the up-to-date treatment of classical mechanical systems and serves as basics and pre-requisite of Quantum Mechanics so that students face least difficulty in entering from classical Physics to Quantum mechanics.

Contents

1. Atomic structure, the thomson model, the rutherford model, alpha-particle scattering, the rutherford scattering formula
2. Electron orbits, sommerfeld model, the bohr model of the atom
3. Atomic spectra of hydrogen atom, the frank-hertz experiments
4. Nuclear motion and reduced mass, the correspondence principle, hydrogenic atom
5. Quantum theory of the hydrogen atom, schrodinger equation for the hydrogen atom, separation of variable
6. Quantum numbers, total quantum numbers, orbital quantum number, magnetic quantum number, angular momentum
7. The normal zeeman effect, electron probability density
8. Many electrons atoms, electron spin, the stern-gerlach experiments, spin-orbit interaction, exclusion principle
9. Electron configuration in many electron-atoms, hund's rules
10. Coupling of angular momenta, coupling schemes, ls-coupling, jj-coupling
11. Origin of spectral lines, selection rules
12. One electron spectra, two-electron spectra

Recommended Texts

1. Foot, C. (2005). *Atomic physics* (1st ed.). New York: Oxford University Press.
2. Brandsen, B. H., Joachian, C. J. & Plivier, T. J. (2003). *Physics of atoms and molecules* (2nd ed.). England: Person Education.

Suggested Readings

1. Krane, K. S. (2019). *Modern physics* (4th ed.). New York: John Wiley & Sons.
2. White, H. E. (2016). *Introduction to atomic spectra* (1st ed.). New Delhi: McGraw-Hill.
3. Haken, H. & Wolf, H. C. (2012). *The physics of atoms and quanta: Introduction to experiments and theory*. Berlin: Springer.
4. Thorne, A. P. (2012). *Spectrophysics.* New York: Chapman & Hall.

PHYS-6124 **Plasma Physics** **3(3+0)**

This is a calculus-based introductory course on plasma physics with maximum emphasis on conceptual understanding, mathematical formulation, interpretation of the fundamental principles of plasma physics and application of the acquired knowledge for solving problems. In this course, students will learn about plasmas, the fourth state of matter. The plasma state dominates the visible universe, and is of increasing economic importance. Plasmas behave in lots of interesting and sometimes unexpected ways. The aim of this course is to describe, in words, the ways in which various concepts in plasma physics come into play in particular situations and discuss the applications and properties of human-made and naturally occurring plasmas. This course provides the students the up-to-date treatment of classical mechanical systems and serves as basics and pre-requisite of Quantum Mechanics so that students face least difficulty in entering from classical Physics to Quantum mechanics.

Contents

1. Occurrence of plasma in nature, definition of plasma, concept of temperature
2. Debye shielding, plasma parameter, criteria for plasma
3. Applications of plasma physics
4. Single-particle motion in uniform E and B fields, single-particle motion in nonuniform B field, single-particle motion in nonuniform E field
5. Time varying E field, time varying B field, adiabatic invariants
6. Fluid description of plasma
7. Fluid equation of motion
8. Fluid drift perpendicular to B, fluid drift parallel to B, the plasma approximation
9. Representation of waves, group velocity
10. Plasma oscillations
11. Electron plasma waves
12. Sound waves, ion waves, validity of plasma approximation
13. Comparison of electron and ion waves
14. Electrostatic electron oscillations perpendicular to B
15. Electrostatic ion waves perpendicular to B
16. The lower hybrid frequency

Recommended Texts

1. Chen, F. F. (2016). *Introduction to plasma physics and controlled fusion* (3rd ed.). New York: Springer.
2. Bittencourt, J. A. (2004). *Fundamentals of plasma physics* (3rd ed.). New York: Springer.

Suggested Readings

1. Bellan, P. M. (2006). *Fundamentals of plasma physics* (1st ed.). Cambridge: Cambridge University Press.
2. Goldston, R. J. (2019). *Introduction to plasma physics*. Bristol: IOP Publishing.
3. Dendy, R. O. (1993). *Plasma physics: an introductory course.* Cambridge: Cambridge University Press.

PHYS-6125 **Quantum Mechanics-II** **3(3+0)**

Quantum physics is arguably the greatest intellectual triumph in the history of human civilization, but to most people it seems like it's too remote and abstract to matter. This is largely a self-inflicted wound on the part of physicists and pop-science writers: when we talk about quantum physics, we usually emphasize the weird and counter-intuitive phenomena but it can be hard to see any connection between these phenomena and everyday life. This course examines the fundamental concepts and techniques of quantum mechanics. Students will develop a self-critical perspective on the theoretical techniques to solve the problems. Rather the task is to develop reflective and critical skills for thinking about creative solutions to for further higher studies and applications. This course provides the students the up-to-date treatment of classical mechanical systems and serves as basics and pre-requisite of Quantum Mechanics so that students face least difficulty in entering from classical Physics to Quantum mechanics.

Contents

1. Orbital angular momentum
2. The eigenvalues and eigen-functions of l^2 and l_z.
3. Matrix representation of angular momentum operators
4. Addition of angular momenta
5. Schrödinger equation in three dimensions
6. 3d problems in cartesian and spherical coordinates
7. Approximate methods
8. Time independent perturbation theory for non degenerate and degenerate levels
9. The variational method
10. The wkb approximation and time dependent perturbation theory
11. Identical particles and second quantization
12. Many particles systems and systems of identical particles
13. The pauli exclusion principle, theory of scattering

Recommended Texts

1. Liboff, R. L. (2002). *Introductory quantum mechanics* (4th ed.). New York: Addison Wesley Publishing Company.
2. Zettili, N. (2009). *Quantum mechanics: concepts and applications* (2nd ed.). New York: John Wiley & Sons.

Suggested Readings

1. Townsend, J. S. (2012). *A modern approach to quantum mechanics* (2nd ed.). New York: University Science Books.
2. Robinett, R. W. (2006). *Quantum mechanics, classical results, modern systems and visualized examples* (2nd ed.). Oxford: Oxford University Press.
3. Gasiorowicz, S. (2003). *Quantum physics* (3rd ed.). New York: Wiley.
4. Griffiths, D. J. (2018). *Introduction to quantum mechanics* (3rd ed.). Cambridge: Cambridge University Press.

PHYS-6126 Solid State Physics-II 3(3+0)

This course is organized in a logical sequence to ensure the utilization of the basic concepts of solid state physics, quantum mechanics, and the crystallography of solids to elaborate their unique properties. Some theoretical aspects which allow us to treat the complex behavior of charge carriers in solids are discussed. Also included, some extended introductions to electronic band structure models, the motion of electrons in energy bands are dealt with simple phenomena encountered in solids. One of the most important phenomena involved in the response of charge carriers under the influence of external fields. Then, the properties of semiconductors will be discussed. Later on, after exploring the origin of magnetism, we put our focus towards the optical properties of solids. Finally, the theoretical and experimental concepts of superconductivity will be discussed in details. This course provides the students the up-to-date treatment of classical mechanical systems and serves as basics and pre-requisite of Quantum Mechanics so that students face least difficulty in entering from classical Physics to Quantum mechanics.

Contents

1. Solid state problem, free electron approximation, density of states
2. Fermi dirac distribution, k-space
3. Concept of fermi energy and the fermi surface
4. Free electron description of heat capacity
5. Electrical conductivity of metals, hall effect
6. Nearly free electron model, origin of the energy gap
7. Bloch functions, concept of hole
8. Periodic & extended zone schemes, motion of electrons in a periodic potential
9. Crystal momentum, effective mass, physical interpretation of the effective mass
10. Kronig-penney model, calculation of band structure
11. tight-binding method
12. Intrinsic carrier concentration, mobility, impurity conductivity donor states, acceptor states
13. Thermal ionization of donors and acceptors
14. Simple description of pn-junction and rectification
15. Transistors, semiconductors heterostructures and outline of solid state lasers

Recommended Texts

1. Pillai, S.O. (2005). *Solid states physics* (6^{th} ed.). New Delhi: New age international limited.
2. Wahab, M. A. (2017). *Solid states physics: structure and properties of materials* (3^{rd} ed.). Oxford: Alpha Science International.

Suggested Readings

1. Ibach, H. & Lüth, H. (2009). *Solid states physics* (4^{th} ed.). New York City: Springer.
2. Ashcroft, N. W. & Mermin, N. D. (2003). *Solid state physics* (1^{st} ed.). Hong Kong: CBS Publishing Asia.
3. H. P. Myers. (2002). *Introductory solid states physics* (2^{nd} ed.). Boca Raton: CRC Press.

PHYS-6127 **Computational Physics** **3(3+0)**

Computational Physics is consisted of techniques to approximate mathematical procedures (e.g., integrals). Approximations are needed because we either cannot solve the procedure analytically (e.g., the standard normal cumulative distribution function) or because the analytical method is intractable (e.g., solving a set of a thousand simultaneous linear equations for a thousand unknowns). By end of this course, participants will be able to apply the Computational Physics for the following mathematical procedures and topics: differentiation, nonlinear equations, and simultaneous linear equations, interpolation, regression, integration, and ordinary differential equations. Additionally, they will be able to calculate errors and implement their relationship to the accuracy of the numerical solutions. This course provides the students the up-to-date treatment of classical mechanical systems and serves as basics and pre-requisite of Quantum Mechanics so that students face least difficulty in entering from classical Physics to Quantum mechanics.

Contents

1. Basics of numerical computation
2. Principles of computer operations
3. Roots of equations (real roots by iterative method, newton raphson method, regulafalsi method bisection method)
4. Computing cardinals: numerical integration (trapezoidal method, simpson’s method and gauss quadrature method)
5. Numerical solutions of odes (euler’s method, modified euler’s method, rk4 method)
6. Interpolation and extrapolation (finite difference, newton forward difference method, newton backward difference method, difference operators
7. Linear interpolation, interpolating polynomials, the lagrange interpolating polynomial) starting with malab
8. Creating arrays and mathematical
9. Operations with arrays using script files and managing data
10. Implementation of numerical analysis in matlab
11. Two dimensional and three dimensional plots
12. User defined functions and function files
13. Symbolic math
14. Modelling and simulations
15. Case study

Recommended Texts

1. Peter, A. S. (1992). *Introduction to numerical methods* (2nd ed.). London: Macmillan Pub. Ltd.
2. Amos, G. (2011). *MATLAB® An introduction with applications* (4th ed.). New York: Wiley.

Suggested Readings

1. Pinter, C. & Dejong, M. (1991). *Introduction to computational physics* (2nd ed.). Massachusetts: Addison-Wesley
2. Macheown, P. K. & Merman, D. J. (1987). *Computational techniques in physics* (4th ed.). Bristol: AdmHilger.

PHYS-6128 **Laser Physics** **3(3+0)**

In this course the students will get a basic understanding of the physics of lasers, their unique properties and potential for applications in optical spectroscopy, material processing, 3-D imaging, chemistry, medicine, optical communications, biomedicine, defense industries, etc. The course provides the students physical foundations for lasers, including light-matter interaction phenomena (absorption, emission and dispersion), propagation of laser beams, laser resonators, rate equations for lasers, transient laser phenomena, principles and characteristics of cw and pulsed lasers, and some topical laser applications as a case study. The course will also treat some common types of laser in more detail, including continuous-wave (cw) and pulsed, gas and solid state lasers. At the end some laser applications will be discussed.

Contents

1. Introduction to lasers, properties of laser beam, electromagnetic waves and photons
2. Energy levels, transition and spectral lines, the metastable level, spontaneous and stimulated emission, stimulated absorption
3. Line shape function, black-body radiation, relation between einstein *a* and *b* coefficients
4. Conditions for large stimulated emissions, gain coefficient and threshold gain coefficient
5. Line-broadening mechanism
6. Population inversion, the three and four-level system
7. Rate equations for two-level, three-level and four-level systems
8. Optical resonators, conditions for steady state oscillation in a two mirror resonator, cavity resonance frequencies
9. Longitudinal and transverse modes in a cavity
10. Pumping process, pulsed vs continuous emission
11. Threshold condition and output power, optimum output coupling, laser tuning
12. Oscillation and pulsations in lasers, q-switching and mode-locking methods
13. Phase velocity and group velocity

Recommended Texts

1. Silfvast, W. T. (2008). *Laser fundamentals.* New York: Cambridge University Press.
2. Milonni, P. W. & Eberly, J. (2010). *Laser physics*. New Jersey: John Wiley & Sons, Inc.

Suggested Readings

1. Hecht, J. (2018). *Understanding lasers*. New Jersey: Wiley-IEEE Press.
2. Hooker, S. & Webb, C. (2010). *Laser physics*. Oxford: Oxford University Press.
3. Svelto, O. (2010). *Principles of lasers*. New York: Springer.
4. Avadhanulu, M. N. & Hemne, P. S. (2001). *An Introduction to lasers-theory and applications*. New Delhi: S. Chand Publishing.

PHYS-6129 **Relativity and Cosmology** **3(3+0)**

In this course, students will be introduced to the field of relativistic physics, learning about its history and its modern branches of study. This course provides students an insight of the principles of special theory of relativity and general theory of relativity and some of their main observational consequences (relativistic kinematics, higher dimensional space-time, cosmology, black holes and others). A student studying the course of Relativity and Cosmology will understand classical as well modern physics and will also acquire the skills to apply principles to new and unfamiliar problems. With this self-paced course, students get engaging lessons, expert instructors who make even the most challenging physics topics simple, and an excellent resource for getting a head start on student's physics graduate degree.

Contents

1. Galilean transformation, existence of ether,
2. Michelson-morley experiment, stellar aberration
3. Einstein's postulates of special relativity
4. Lorentz transformations
5. Relativity of simultaneity
6. Ttime dilation (twins paradox)
7. Length contraction (ladder paradox)
8. Velocity transformation and velocity addition
9. Relativistic mechanics
10. Minkowski spacetime, line element
11. Four-vectors, force equation in relativity
12. Rest mass, kinetic and total energy
13. Conservation of energy and momentum
14. Elements of tensor calculus, manifolds and coordinates, curves and surfaces
15. Tensor fields, lie derivative
16. Geodesics, parallel transport
17. Riemann tensor, metric tensor, christoffel symbols
18. General relativity, principles of general relativity
19. Equation of geodesics, einstein's field equations
20. Cosmology, newtonian cosmology, cosmological redshift
21. Hubble's law, the big bang, expansion rate

Recommended Texts

1. Cheng, T. (2015). *A college course on relativity and cosmology* (1st ed.). Oxford: Oxford University Press.
2. Forshaw, J. R. & Smith, A. G. (2009). *Dynamics and relativity* (1st ed.). New York: Wiley.

Suggested Readings

1. McMohan, D. (2006). *Relativity demystified* (1st ed.). New York: Mc Graw-Hill.
2. McComb, W. D. (1999). *Dynamics and relativity* (2nd ed.). Oxford: Oxford University Press.
3. Narlikar, J. V. (2002). *Introduction to cosmology* (3rd ed.). Cambridge: Cambridge University Press.

PHYS-6130 Nuclear and Elementary Particle Physics 3(3+0)

In Nuclear physics we study about atomic nuclei, their constituents and interactions. Other forms of nuclear matter are also studied. Nuclear physics should not be confused with atomic Physics, which studies the atom as a whole, including its electrons. Particle Physics evolved out of nuclear physics.In nuclear physics we study about introduction of nucleus, accelerators, different types of detectors, different types of nuclear forces and their interactions and about particle physics. The aim of this course is use their conceptual understanding of the Properties of Nucleus, use their ability to manage and operate different kind of detectors, have the knowledge about the particle accelerator and can use it to work on this machine for advance research, apply this knowledge in practical situations.

Contents

1. Basic properties of nucleus: size and mass of the nucleus
2. Nuclear spin, magnetic dipole moment
3. Eelectric quadropole moment
4. Parity and statistics, detectors, passage of charged particle through matter, ionization chamber, proportional counter, scintillation counter
5. Semi-conductor detector, emulsion technique, bubble chamber
6. Particle accelerators: linear accelerator, van de graff, betatron, synchrocyclotron, proton synchrotron
7. Nuclear forces, yukawa theory, proton-proton and neutron-proton scattering, charge independence of nuclear force, isotopic spin
8. Liquid drop model, shell model, collective model, conservation laws of nuclear reaction, q-value of nuclear reaction
9. Threshold energy, transmutation by photons, proton, deuterons and alpha particles, excited states of nucleus, energy levels, level width, cross section from nuclear reactions
10. Breit-wigner formula, direct reactions
11. Theory of fission and spontaneous fission
12. Nuclear chain reaction and applications, thermonuclear reactions, fusion and thermonuclear process
13. Energy released in nuclear fusion, formation of heavy elements
14. Semi-carbon nitrogen cycle controlled nuclear fusion
15. Introduction, fundamental interactions, classification of elementary particles, parameters of elementary particles, the mass less bosons
16. The leptons, the mesons, the baryons, the eight fold way, quarks, color, charm

Recommended Texts

1. Wong, S. M. (2004). *Introductory nuclear physics* (2^{nd} ed.). Weinheim: Wiley
2. Chatwa, G. (2007). *Nuclear physics* (2^{nd} ed.). New Delhi: Dominant Publisher and Distribution.

Suggested Readings

1. Wiedemann, H. (2007). *Particle accelerator physics* (2^{nd} ed.). Berlin: Springer.
2. Krane, S. (1987). *Introductory nuclear physics* (3^{rd} ed.). New Jersey: Wiley.
3. Bernardeau, F., Grojean, C. & Dalibard, J. (2007). *Particle physics and cosmology*. Amsterdam: Elsevier Science.

PHYS-6131 Advanced Electronics 3(3+0)

Advance Electronics is the course of zero and one. This course includes the theoretical and practical approach for designing of computer. This course starts with number system and their interconversions which is the basic for designing of a digital system. The course also contains different types of logic circuits, i.e. combinational logic and sequential logic circuits. The different types of counter and register circuits are designed. The basic architecture of microprocessor and microcontroller is discussed and the concepts of RAM and ROM along with designing are given. After this course the students will be able to design the small or large digital circuits. They will also be able to study the logic gates and implementation of Boolean functions using different logic families.

Contents

1. Number systems and operations (number systems their introversion)
2. Codes (bcd, excess-3, gray) error detection and correction codes, parity codes, and 7-segment display code logic
3. Gates and related devices
4. Logic families- significance and types
5. Boolean algebra and simplification techniques
6. Combinational logic design, and flip-flops
7. Sequential logic circuits (registers and application of shift register), ripple counters, synchronous counter
8. Microprocessors, introduction to microprocessors, inside a microprocessor, and arithmetic logic unit (alu)
9. Processor family, intel microprocessor hierarchy
10. Microcontrollers, introduction to the microcontroller, applications, inside the microcontroller
11. Central processing unit (cpu)
12. Random access memory (ram), read only memory (rom)
13. Special-function registers
14. Peripheral components
15. Microcontroller architecture, architecture to access memory, and 8-bit microcontrollers

Recommended Texts

1. Mano, M. M. (2017). *Digital logic and computer design* (5th ed.). New Delhi: Pearson.
2. Tokheim, R. L. (2013). *Digital electronics: principles and applications* (8th ed.). Boston: MacGraw-Hill education.

Suggested Readings

1. Floyd, T. L. (2014). *Digital fundamentals* (11th ed.). New Jersey: Prentice Hall, Pearson.
2. Morris, M., Michael, M. & Ciletti, D. (2013). *Digital design* (5th ed.). Upper Saddle River: Prentice Hall, Pearson.
3. Kumar, A. A. (2016). *Fundamentals of digital circuits* (4th ed.). New Delhi: PHI Learning.
4. Boylestad, R. & Nashelsky, L. (2002). *Electronic devices and circuit theory*. New Jersey: Pearson Prentice Hall.

PHYS-6132 Physical and Geometrical Optics 3(3+0)

Optics is a branch of physics that deals with the determination of behavior and the properties of light, along with its interactions with the matter and also with the instruments which are used to detect it. There are two major branches of optics, physical and geometrical. Physical optics deals primarily with the nature and properties of light itself. Geometrical optics has to do with the principles that govern the image-forming properties of lenses, mirrors, and other devices that make use of light. This course is designed to help students gain an understanding of the fundamental principles of optics and photonics. It is primarily a theoretical course with some application to optical design. The course focuses on physical optics including the Fresnel Laws of refraction and reflection, interference, Fourier analysis and diffraction. This course also covers the basic concepts of geometrical ray optics and aberrated imaging needed in further optician education and professional work.

Contents

1. Light - a historical perspective
2. Production and measurement of light: electromagnetic spectrum, black body radiations, source of radiations, detectors of radiation
3. Huygens' principal, fermats' principle, reflection in plane mirror, reflection through plane surfaces, imaging by an optical system, thin lenses
4. The thick lens, the ray tracing
5. Cylindrical lenses, combining cylindrical powers, astigmatism
6. Ray and wave aberrations, spherical and chromatic aberration, aberrations in vision
7. Controlling light through optical system: controlling image brightness and field of view
8. Optical instruments: prisms, camera, magnifiers and eyepieces, microscopes, telescopes
9. Light as waves: harmonic waves, electromagnetic waves, doppler effect, superposition principle, standing waves
10. Interference phenomena: two-beam interference, young's double slit experiment, interference in dielectric films
11. Interference applications: newton's rings, film thickness measurement by interference, the michelson interferometer, holography
12. Polarized light: modes of polarization, polarizing elements
13. Fraunhofer diffraction: diffraction from a single slit, rectangular and circular apertures, resolution, multiple slit diffraction
14. Fiber optics: optics of propagation, sources and detectors

Recommended Texts

1. Pedrotti, F. L., Pedrotti, L. S. & Pedrotti, L.M. (2008). *Introduction to optics* (3rd ed.). New Delhi: Pearson Education.
2. Eugene, H. & Ganesan, A. R. (2012). *Optics* (4th ed.). New Delhi: Pearson Education.

Suggested Readings

1. Garbovskiy, Y. A. & Glushchenko, A. V. (2017). *A practical guide to experimental geometrical optics*. New York: Cambridge University Press.
2. Freenan, M. H. & Hull, C. C. (2013). *Optics* (11th ed.). Berlin: Elsevier.
3. Sharma, K. K. (2006). *Optics: principles and applications.* New York: Elsevier.

PHYS-6133 Physics of Nanotechnologies 3(3+0)

This course introduces the concepts of nanomaterials and their types, importance of nanometer scale and origins of nanoscopic behaviour along with some applications from different fields e.g, industry, agriculture, medicine etc. Secondly it elaborates different techniques of fabrication of nanomaterials using different top down and bottom up approaches e.g, different lithography techniques and wet chemical methods as well as how to study their different properties e.g, surface, structural, physical and chemical properties etc. At the end of this course students will be able to know why we need nanotechnology, what are its applications, what are the challenges for this technology regarding productions of nanomaterials and nanodevices.

Contents

1. Introduction to nano physics
2. Importance, types of nanomaterials and their applications
3. Origin of observed differences between nanoscopic and macroscopic materials
4. Carbon based nanomaterials
5. Graphene: properties and application of graphene, electrical & thermal conductivity, mechanical strength, elasticity, optical properties
6. Carbon nanotubes: properties and applications of carbon nanotubes, electrical & thermal conductivity, mechanical strength, elasticity, optical properties
7. Thin film deposition techniques
8. Physical vapour deposition techniques: pulsed laser deposition, sputtering, molecular beam epitaxy, electron beam evaporation
9. Chemical vapour deposition techniques: chemical vapour deposition
10. Nanofabrication techniques
11. Top down nanofabrication techniques: optical lithography, e-beam lithography, nano-imprint lithography
12. Bottom up nanofabrication techniques: chemical reduction, hydrothermal, co-precipitation methods
13. Nanostructures characterization techniques: surface and structural characterization
14. Surface analysis: scanning electron microscopy, transmission electron microscopy, atomic force microscopy, scanning tunneling microscopy
15. Structural analysis: x-ray diffraction

Recommended Texts

1. Wolf, E. L. (2015). *Nanophysics and nanotechnology: An introduction to modern concepts in nanoscience*. New York: John Wiley & Sons.
2. Chrisey, D. B. & Hubler, G. K. (1994). *Pulsed laser deposition of thin films*. New York: Wiley-Interscience

Suggested Readings

1. Wiesendanger, R. (2013). *Scanning probe microscopy: analytical methods*. New York: Springer Science & Business Media.
2. Goldstein, J. I., Newbury, D. E., Michael, J. R., Ritchie, N. W., Scott, J. H. & Joy, D. C. (2017). *Scanning electron microscopy and x-ray micro analysis.* New York: Springer.

PHYS-6134 Methods of Experimental Physics 3(3+0)

The main objective of this course is to give students a brief introduction of some important experimental techniques related to experimental research in physics which are currently being used in different modern research labs e.g, vacuum technology to make contamination free samples at nanoscale and different type of sensors to measure different physical parameters e.g, pressure, temperature, magnetic field etc. Vacuum technology includes concepts of fundamental vacuum physics, importance, applications, ranges creation and measurement of vacuum, hurdles regarding creation of vacuum and mathematical modeling of fluid dynamics and pumping process. This course also provides a comprehensive introduction to construction and working of different vacuum related devices and different types of sensors.

Contents

1. Introduction to vacuum physics: importance, ranges and applications of vacuum
2. Molecular description of gases: kinetic molecular theory of gases, continuum and molecular states of gases, mean free path, molecular number density, impingement rate
3. Surfaces processes: scattering of a molecule from a surface, adsorption and desorption processes and their mathematical modeling
4. Outgassing: origins, importance and mathematical modeling of outgassing rate due to different sources e.g, desorption, diffusion & permeation
5. Sputtering: mechanism, factors affecting sputtering yield, applications of sputtreing
6. Gas flow: continuum and molecular flow of gases
7. Conductance and pumping speed, mathematical modeling for conductance of long, short pipe and an aperture both for continuum and molecular flow regimes
8. Pumping process, pump down time and ultimate pressure
9. Vacuum pumps: rotary & root pumps, turbo molecular pump, ionic and titanium sublimation pumps
10. Vacuum gauges: diaphragm & capacitance diaphragm guages, spin rotor, penning & magnetron gauges
11. Sensor technology: temperature sensors, optical sensors, magnetic sensors, fluid flow sensors, metal detectors

Recommende Texts

1. Chambers, A. (2004). *Modern vacuum physics* (1st ed.). London: CRC Press.
2. Fraden, J. (2010). *A handbook of modern sensors: physics, design and applications (4th ed.)*. New York: Springer.

Suggested Readings

1. Hoffman, D. M. Thomas, J. H. & Singh, B. (1997). *Handbook of vacuum science and technology.* London: Elsevier.
2. Yoshimura, N. (2007). Vacuum *technology: Practice for scientific instruments*. New York: Springer.
3. Martin, L., Weissler, G.L. & Carlson, R. W. (1979). *Methods of experimental physics: vacuum physics and technology.* New York: Springer

PHYS-6135 **Advanced Electronics LAB** **3(3+0)**

This lab is the practical approach of theoretical concepts of "Advanced Electronics" already studied in pervious semester. The designing of different circuits is done and verified by using the truth tables. The clock pulse is also designed and studies the operation of different types of counter. This lab provides the students with a broad understanding of theory of advance electronic by the implementation to empower them to think creatively and critically about scientific problems and experiments (thought as well real-life). After this lab, the students will be able to design any circuit from it's logic diagram. They will also be able to understand the design and working of consumer/industrial electronics, communications, embedded systems, microprocessors, and security equipments widely used in everyday life. This laboratory course will help the students in getting familiarized with basic electrical measurement techniques, enhancing ability to apply electrical theory to practical problems, practice in recording and reporting technical information, familiarization with electrical safety requirement.

Contents

1. Implementation of logic using different logic families
2. Using ic's construct and study rs, jk (master slave), t, and d flip-flops
3. Design and study of a half and full adder with different boolean expression using ic's
4. Design and study different combinational circuit(bcd adder,7-segment decoder, comparator encoder, multiplexer circuits)
5. To study combinational lock and led sequencer circuits
6. Synchronous and asynchronous bcd counters, memory shift register with ic's
7. Design and study of decoder, encoder, multiplexer circuits
8. Design and study the 4-bit odd and even parity circuits

Recommended Texts

1. Floyd, T. L. (2014). *Digital fundamental* (11th ed.). New Jersey: Prentice Hall, Pearson.
2. Mono, M. M. & Ciletti, M. D. (2013). *Digital design* (5th ed.). Upper Saddle River: Prentice Hall, Pearson.

Suggested Readings

1. Mono, M. M. (2017). *Digital logic and computer design* (5th ed.). New Delhi: Pearson.
2. Tokheim, R. L. (2013). *Digital electronics: principles and applications* (8th ed.). OH: MacGraw-Hill Education.
3. Kumar, A. A. (2016). *Fundamentals of digital circuits,* (4*th* ed.). New Delhi: PHI Learning.
4. Robert, L. B. & Nashelsky, L. (2005). *Electronic devices and circuit theory* (9th ed.). New Jersey: Prentice Hall.
5. Mitchel, E. S. (2003). *Grob's basic electronics* (13th ed.). New York: McGraw-Hill Education.

PHYS-6136 **Introduction to Quantum Computing** **3(3+0)**

Quantum computing is the use of quantum mechanical phenomena to perform computation and the computers performing quantum computations are known as quantum computers. These computers are supposed to perform much better than their contemporary counterparts. Quantum computation is a subfield of quantum information science. Quantum computing is the major impetus to the development of new general quantum technologies. This course offers a comprehensive introduction to quantum computing. The main objectives of this introductory course is to introduce the background material in mathematics and physics necessary to understand quantum computation and to develop in detail the central results of quantum computation.

Contents

1. Computer technology and historical background
2. Basic principles and postulates of quantum mechanics: quantum states, evolution, quantum measurement, superposition, quantization from bits to qubits, operator function, density matrix, schrodinger equation
3. Schmidt decomposition, epr and bell's inequality
4. Quantum computation: quantum circuits
5. Single qubit operation
6. Controlled operations
7. Measurement
8. Universal quantum gates, single qubit and cnot gates
9. Breaking unbreakable codes: code making
10. Trapdoor function, one time pad, rsa cryptography
11. Code breaking on classical and quantum computers, schor's algorithm
12. Quantum cryptography: uncertainty principle
13. Polarization and spin basis, bb84, bb90, and ekert protocols
14. Quantum cryptography with and without eavesdropping
15. Experimental realization
16. Quantum search algorithm

Recommended Texts

1. Nielson, M. A. & Chuang, I. L. (2000). *Quantum computation and quantum information* (2nd ed.). Cambridge: Cambridge University Press.
2. McMahon, D. (2007). *Quantum computing explained* (1st ed.). New York: John Wiley & Sons.

Suggested Readings

1. Bouwmester, P., Ekert, A. & Zeilinger, A. (2000). *The physics of quantum information: quantum cryptography, quantum teleportation, quantum computation*. Berlin: Springer Verlag.
2. Williams, C.P. (2011). *Exploration in quantum computation* (2nd ed.). Berlin: Springer Verlag.
3. Brylinsky, A. K. & Chen, G. (2002). *Mathematics of quantum computation*. London: Chapman & Hall/CRC.

PHYS-6137 **Particle Physics** **3(3+0)**

Particle physics has revolutionized the way we look at the universe. Along the way, it's made significant impacts on other fields of science, improved daily life for people around the world and trained a new generation of scientists and computing professionals.Because particle physics asks big questions—the biggest in all of science, we need new, unique and often very large equipment.Each year, tens of millions of patients receive X-ray, proton and ion therapy to treat cancer at more than ten thousand hospitals and medical facilities around the world. The aim of this course is ofcourse;enable particle physicists to learn about the universe around us. Over the past half century, particle physicists have formulated the Standard Model, a beautiful framework that explains the visible universe from the smallest to the largest scales.

Contents

1. Particle classification, quantum numbers
2. Leptons, hadrons, baryons, mesons, quarks
3. The fundamental interactions, the electromagnetic coupling, the strong coupling
4. The weak coupling
5. Symmetry transformation and conservation laws
6. Translation in space, rotation in space
7. The group su (2), systems of identical particles, parity, iso-spin charge conjugation, time reversal
8. G parity, cpt theorem, the electromagnetic field, gauge invariance
9. Maxwell's equations, polarization ad photon spin
10. Angular momentum, parity and c parity of photon
11. Hadron spectroscopy, formation experiment, partial wave formalism and the optical theorem
12. The breit-wigner resonance formula, baryon resonances, phase space considerations
13. Production experiments, the quark model, the group su (3)
14. Quarks, hadrons baryons, mesons in quark model, heave meson spectroscopy
15. The quarkonium model
16. The standard model (qualitative treatment only)
17. Unification of weak and electromagnetic interactions
18. Glashow-salam-weinberg model

Recommended Texts

1. Griffiths, D. (2008). *Introduction to elementary particles* (2^{nd} ed.). Weinheim: Wiley
2. Riazuddin, Fayyazuddin (2012). *Quantum mechanics* (2^{nd} ed.). Singapore: World Scientific.

Suggested Readings

1. Povh, B. Rith, K. & Scholz, C. (2006). *Particles and nuclei: an introduction to the physical concepts*(5^{th} ed.). Berlin: Springer.
2. Bjorken, J. D. & Drell, S.D. (1998). *Relatvistic quantum mechanics* (1^{st} ed.). New York: McGraw Hill.
3. Halzen, F. & Martin, A. D. (1984). *Quarks and leptons* (1^{st} ed.). New Jersey: Wiley.

MSc

PHYSICS

PHYS-6111 Methods of Mathematical Physics-I 3(3+0)

This course provides a wide range of analytical mathematical techniques essential to the solution of advanced problems in physics. The main objective is to have an in-depth understanding of the basics of complex analysis, residue theorem and its applications to integral solving techniques. This course enables the student to solve for orthogonal functions, Beta functions, Factorial functions, Gamma functions Digamma and Poly-gamma functions and to compute their integral transforms. It also enables the student to apply special functions, their kinds and recurrence relations used in physics problems and to solve the second order differential equations using the concept of Sturm-Liouville theory, Green's functions and eigen valued problems.

Contents

1. Function of complex variables and basic review
2. Analytic functions, harmonic functions
3. Cauchy riemann equations
4. Differentiation and integration of complex variables
5. Sequence and series in complex numbers
6. Calculus of residues and its basic concept
7. Evaluation of different integral types in residues
8. The gamma function (definition and its properties)
9. Factorial notations
10. Digamma and poly-gamma functions
11. Beta functions and its mathematical notations
12. Incomplete beta functions
13. Stirling's series
14. Eigen functions and orthogonal functions
15. Strum-liouville theory
16. Green's functions
17. Bessel functions and its first kind
18. Orthogonality of bessel function
19. Generating function and recurrence relations of bessel function

Recommended Texts

1. Arfken, G. B., Weber, H. J. & Harris, F. E. (2011). *Mathematical methods for physicists* (7^{th} ed.). New York : Elsevier Science.
2. Kreyszig, E. (2011). *Advanced engineering mathematics* (10th ed.). New York: Wiley.

Suggested Readings

1. Spiegel, M. R., Lipschutz, S., Schiller, J. J. & Spellman, D. (2009). *Schaum's outline of complex variables* (2^{nd} ed.). New York: McGraw Hill Professional.
2. Wong, C. W. (2013). *Introduction to mathematical physics* (2^{nd} ed.). Oxford: Oxford University Press.
3. Kakani, S. L. & Hemrajani, C. (2010). *Mathematical physics* (2^{nd} ed.). New Delhi: CBS Publishers.

PHYS-6112 Classical Mechanics –I 3(3+0)

The fundamental goal of this course is to create understanding in students to classical mechanics and its applications. The focus in this course will be given to develop knowledge of the physical concepts and mathematical methods of classical mechanics to develop skills in formulating and solving physics problems. Students will learn the use of Newton's laws of motion, conservation theorems to solve advanced problems involving the dynamic motion of classical mechanical systems. The studies will be extended to oscillatory objects, gravitation and systems of particles. This course provides the up-to-date treatment of classical mechanical systems so that students face least difficulty in understanding the advance topics covered in classical Mechanics II course.

Contents

1. Historical background of classical mechanics
2. Concept of scalars vectors and coordinates transformations
3. Properties of orthogonal matrix
4. Vector products and proof of various identities of vectors
5. Velocity and acceleration in various coordinates
6. Gauss's divergence theorem and stokes theorem
7. The newtonian formulation of mechanics and kinematics of particle motion
8. Force and types of force, problems about constant force acting upon the body and motion on inclined plane
9. Motion of the body in resistive medium solving the problem free falling object and motion of projectile and atwood's machine
10. Conservation theorems: linear momentum, angular momentum and conservation of energy equilibrium and its type
11. Motion in electromagnetic field, equilibrium and nature of equilibrium
12. Oscillatory motion, free oscillator in one and two dimension
13. Damped oscillator and its types, under-damped, critically damper and over damped oscillator
14. Forced oscillator
15. Physical oscillatory systems and electrical oscillation
16. Nonlinear oscillations.
17. Gravitation: gravitation and gravitational potential
18. Poisson's equations. Lines of force and equi-potential surfaces

Recommended Texts

1. Thornton, S. T. & Marion, J. B. (2012). *Classical dynamics of particles and systems* (5th ed.). New York: Thomson Brooks/Cole
2. Goldstein, H., Charles, P. P. & Safko J. L. (2001). *Classical mechanics* (3rd ed). Massachusetts: Addison Wesley Reading.

Suggested Readings

1. Taylor, J. R. (2005). *Classical mechanics*. California: University Science Books.
2. Tom, W. B. K. (2005). *Classical dynamics* (5th ed.). London: Imperial College Press.
3. Finn, J. M. (2010). *Classical dynamics.* Boston: Jones and Bartlett Publishers.

PHYS-6113 Electrodynamics-I 3(3+0)

This course is all about one of the four known forces (gravitational force, electromagnetic force, weak nuclear force and strong nuclear force) of nature – electromagnetic force. The course will cover a number of fundamental topics in electromagnetism, including a brief review of basic concepts, electrostatics in free space, Poisson's and Laplace's equations, solution of boundary-value problems, Method of Images, Multipole expansion and re-formulation of electrostatics inside matter. In addition to expanding the application of these concepts to more general problems, a significant part of the course will involve the development of expertise in more advanced mathematical techniques, including especially the always interesting Green's functions, Bessel's functions, Legendre's & associated Legendre's functions and spherical harmonics.

Contents

1. Differential calculus: gradient; divergence; curl
2. Integral calculus: gradient theorem; green's theorem; stokes' theorem
3. Orthogonal coordinate systems: cartesian coordinates
4. Cylindrical coordinate; spherical coordinates
5. Electrostatics in free space: coulomb's law for electric force, electric field and electric potential due to a single point charge, discrete charge distribution and continuous charge distributions
6. Gauss's law; electrostatic boundary conditions
7. Electrostatic energy for discrete and continuous charge distributions; conductors
8. Capacitors: parallel-plate capacitor
9. Cylindrical capacitor; spherical capacitor
10. Boundary-value problems: solutions of laplace's equation in cartesian, cylindrical and spherical coordinates
11. Poisson's equation
12. Method of images; other image problems
13. Electric field and electric potential of an electric dipole; multipole expansion of electric potential
14. Electrostatics inside matter: polarization; electric field and electric potential of a polarized object; bound charges
15. Gauss's law in the presence of dielectrics; boundary conditions on electric displacement; electrostatic energy in dielectrics

Recommended Texts

1. Griffiths, D. J. (2007). *Introduction to electrodynamics* (4th ed.). New York: Prentice Hall.
2. Cheng, D. K. (2013). *Field and wave electromagnetics* (2nd ed.). New York: Pearson.

Suggested Readings

1. Vanderlinde, J. (2005). *Classical electromagnetic theory* (2nd ed.). New York: Springer.
2. Zahn, M. (2003). *Electromagnetic field theory: a problem solving approach* (1st ed.). Florida: Krieger Publishing Co.
3. Fleisch, D. (2008). *A student's guide to Maxwell's equations* (1st ed.). Cambridge: Cambridge University Press.

PHYS-6114 **Electronics** **3(3+0)**

Electronics is the application of devices controlling the flow of electrons. The nonlinear behavior of active components and their ability to control electron flows makes amplification of weak signals possible. Electronics is widely used in information processing, telecommunication, and signal processing. The ability of electronic devices to act as switches makes digital information processing possible. Interconnection technologies such as circuit boards, electronics packaging technology and other varied forms of communication infrastructure complete circuit functionality and transform the mixed components into a regular working. This course covers the basic concepts of Electronics which helps students to learn and understand it clearly. This course provides the students the up-to-date treatment of classical mechanical systems and serves as basics and pre-requisite of Quantum Mechanics so that students face least difficulty in entering from classical Physics to Quantum mechanics.

Contents

1. Semiconductor diode and application, semiconductor diode, characteristics curves
2. Dc & ac resistance, diode equivalent circuit, series and parallel diode configuration with dc load
3. Rectification, half and full wave rectifier circuit with and without filter, zener diode, led
4. Bbjt's: transistor and transistor operation, transistor configurations (cb, ce, cc)
5. Current amplification factors, load line and operating conditions
6. Dc biasing (voltage divider bias c-e amplifier), design of voltage divider bias c-e amplifier
7. Negative feedback amplifiers, general characteristics of negative feedback amplifiers
8. Classification of negative feedback amplifiers, voltage series feedback amplifier. Integrated amplifier: the differential amplifier (modes of operation, common mode rejection ratio)
9. Operational amplifier and its parameters, op-amp configuration with negative feedback, op-amp applications (voltage summing, voltage buffer, voltage comparators)
10. Op-amp as differentiator and integrator oscillators: oscillator principles and conditions for oscillation, oscillator with lc feedback circuits

Recommended Texts

1. Boylestad, R. & Nashelsky, L. (2002). *Electronic devices and circuit theory*. New Jersey: Pearson Prentice Hall.
2. Floyd, T. L. (2007). *Principles of electric circuits*. New Jersey: Pearson Prentice Hall.

Suggested Readings

1. Halliday, D., Resnick, R. & Walker, J. (2014). *Fundamental of physics* (10^{th} ed.). New York: Wiely.
2. Young, H. D., Freedman, R. A. & Ford, A. L. (2019). *University physics* (15^{th} ed.). New York: Pearson.
3. Beiser, A. (2003). *Concepts of modern physics* (6^{th} ed.). New York: McGraw-Hill Education.

PHYS-6121 **Modern Physics Lab** **3(0+3)**

20th century seen new scientific theories with experimental developments known in language of physics as Modern Physics. This course is developed in order to familiarize the students with some of the theories of that era with experimental proofs and to develop a scientific behavior in experimental physics for research fields. These experiments deals with measurements of charge to mass ratio of an electron, particle and wave nature (wave-particle duality) of light, detection and measurements of radioactive radiation, measurement of speed of light, measurement of excitation potential of Mercury, measurement of wavelength of Sodium light, diffraction pattern and deviation of light when light changes its medium ,etc. This course provides the students the up-to-date treatment of classical mechanical systems and serves as basics and pre-requisite of Quantum Mechanics so that students face least difficulty in entering from classical Physics to Quantum mechanics.

Contents

1. To determine the Cauchy's constants using spectrometer
2. Measurement of wavelength of mercury light using Michelson interferometer
3. To determine the charge to mass ratio (e/m) of electron by fine beam tube method
4. Determination of speed of light using optical fiber
5. Characteristics of G. M tube, radiation detection, shielding and analysis
6. Radio frequency measurements (determination of dielectric constants of solids)
7. To study the characteristics of a Geiger-Muller counter and to examine the attenuations of beta particles in Al-and Pb foils
8. Measurement of the spectrum of gamma rays from a radioisotope, shielding and attenuation of gamma rays
9. The Frank-hertz experiment (measurement of excitation potential of Hg)
10. AC circuits and dielectric constants of water and ice
11. Radio frequency measurement, skin effect, etc
12. Experiments with transmission lines
13. Source strength of Co60 by gamma coincidence methods
14. To examine the stopping-power of various substances for thermal neutrons
15. Determination of the Rydberg constant from the spectrum of hydrogen
16. To study the Zeeman effect for a line in the spectrum of helium
17. Electron spin resonance (E.S.R.) by microwave absorption
18. The measurement of the Hall Effect in germanium and silicon

Recommended Texts

1. Mark, H. & Olsono, H.T. (2004). *Experiments in modern physics*. New York: McGraw-Hill
2. Melissinos, A.C. (2008). *Experiments in modern physics.* New York: Academic press.

Suggested Readings

1. Melissinos, A. C. & Napolitano, J. (2003). *Experiments in modern physics.* New York: Gulf Professional Publishing.
2. Shamos, M. H. (2012). *Great experiments in physics: first hand accounts from Galileo to Einstein.* New York: Courier Corporation.

PHYS-6116 Methods of Mathematical Physics-II 3(3+0)

This course provides a wide range of analytical mathematical techniques essential to the solution of advanced problems in physics. The main objective is to develop intuition towards formulating physical phenomena in mathematical language and gain an appreciation of the analytical methods that are most commonly used to solve problems in physics. This course has an in-depth understanding of the basics of Legendre functions, Hermite functions, Laguerre functions, Chebyshev functions and its applications to problem solving techniques. It enables the student to solve for Fourier series, Fourier integral and compute their Fourier transforms. It also enables the student to apply Laplace transform and inverse Laplace transform to solve the initial value problems.

Contents

1. Fourier series
2. Basic definition and properties of fourier series
3. Complex fourier
4. Gibbs phenomenon
5. Fourier integral
6. Fourier transforms
7. Discrete fourier transform
8. Legendre functions
9. Generating function
10. Recurrence relations
11. Orthogonality
12. Associated legendre functions
13. Legendre functions of second kind

Recommended Texts

1. Arfken, G. B., Weber, H. J. & Harris, F. E. (2011). *Mathematical methods for physicists* (7th ed.). New York : Elsevier Science.
2. Kreyszig, E. (2011). *Advanced engineering mathematics* (10th ed.). New York: Wiley.

Suggested Readings

1. Spiegel, M. R., Lipschutz, S., Schiller, J. J. & Spellman, D. (2009). *Schaum's outline of complex variables* (2nd ed.). New York: McGraw Hill Professional.
2. Wong, C. W. (2013). *Introduction to mathematical physics* (2nd ed.). Oxford: Oxford University Press.
3. Kakani, S. L. & Hemrajani, C. (2010). *Mathematical physics* (2nd ed.). New Delhi: CBS Publishers & Distributors.

PHYS-6117 Classical Mechanics- II 3(3+0)

The aim of this course is to continue, merge and extend the studies of Classical Mechanics I PHYS-302 in previous semester. Its ideas also link with other courses like quantum mechanics and condensed matter. The fundamental goal of this course is to create understanding in students to classical mechanics and its applications. This course provides the students the up-to-date treatment of classical mechanical systems and serves as basics and pre-requisite of Quantum Mechanics so that students face least difficulty in entering from classical Physics to Quantum mechanics. The purpose of the course is to make the students capable in formulating and solving physics problems. This course provides the students the up-to-date treatment of classical mechanical systems and serves as basics and pre-requisite of Quantum Mechanics so that students face least difficulty in entering from classical Physics to Quantum mechanics.

Contents

1. Some methods in the calculus of variations
2. Euler's equation, "first and second form" of euler's equation
3. Kinematics of system of particles
4. Collision between particles, centre of mass and lab co-ordinate system, elastic collision in lab and cm coordinate system
5. Scattering by central force field
6. Rutherford's scattering formula
7. Rocket motion
8. Limitations of newtonian mechanics, generalized co-ordinates and constraints, virtual displacement and virtual work
9. D' alembert's principle
10. Lagrange 's equation of motion
11. Hamilton's principle and lagrange's equation
12. Hamiltonian of dynamical system
13. Hamilton's canonical equations
14. Poisson bracket and their properties
15. Central force motion
16. Two body problem and reduced mass

Recommended Texts

1. Thornton, S. T. & Marion, J. B. (2012). *Classical dynamics of particles and systems* (5th ed.). New York: Thomson Brooks/Cole
2. Goldstein, H., Charles, P. P. & Safko J. L. (2001). *Classical mechanics.* (3rd ed). Massachusetts: Addison Wesley Reading.

Suggested Readings

1. Taylor, J. R. (2005). *Classical mechanics*. California: University Science Books.
2. Tom W. B. K. (2005). *Classical dynamics* (5th ed.). London: Imperial College Press.
3. Finn J. M. (2010). *Classical dynamics.* Boston: Jones and Bartlett Publishers.

PHYS-6118 **Electrodynamics-II** **3(3+0)**

This course is the second in a series on Electrodynamics beginning with Electrodynamics-I (PHYS-6113). The course will cover various topics in electromagnetism, including equation of continuity, magnetostatics in free space, re-formulation of magnetostatics inside matter, magnetic media, electrodynamics, Faraday's law of induction, Maxwell's equations in free space & inside matter and electromagnetic waves in free space & inside matter. The course will not only review the basic material, students learned in Electricity and Magnetism-II (PHYS-5105) but will go beyond in both contents as well as mathematical sophistication. A solid understanding of how to manipulate the complex mathematical equations will give the students a much stronger toolbox for confidence in analyzing a wider range of geometries and problems.

Contents

1. Electric currents: line currents, surface currents, volume currents, equation of continuity
2. Magnetostatics in free space: biot-savart law for magnetic force, magnetic field and magnetic vector potential due to line, surface and volume currents
3. Solutions of laplace's vector equation and poisson's vector equation
4. Ampere's law, magnetostatic boundary conditions
5. Magnetic field and magnetic vector potential of a magnetic dipole, multipole expansion of magnetic vector potential
6. Magnetostatics inside matter: magnetization; magnetic field and magnetic vector potential of a magnetized object, bound currents
7. Ampere's law inside matter; boundary conditions on magnetic displacement, paramagnetic, diamagnetic and ferromagnetic materials
8. Electrodynamics: ohm's law, electromotive force
9. Faraday's law
10. Lenz's law
11. Inductors, mutual and self inductance, energy stored in magnetic field
12. Maxwell's equations in free space for static and dynamic cases, displacement current
13. Maxwell's equations inside matter for static and dynamic cases, polarization current
14. Electromagnetic waves in free space
15. Electromagnetic waves inside matter

Recommended Texts

1. Griffiths, D. J. (2007). *Introduction to electrodynamics* (4th ed.). New York: Prentice Hall.
2. Cheng, D. K. (2013). *Field and wave electromagnetics* (2nd ed.). New York: Pearson.

Suggested Readings

1. Vanderlinde, J. (2005). *Classical electromagnetic theory* (2nd ed.). New York: Springer.
2. Zahn, M. (2003). *Electromagnetic field theory: a problem solving approach* (1st ed.). Florida: Krieger Publishing Co.
3. Fleisch, D. (2008). *A student's guide to Maxwell's equations* (1st ed.). Cambridge: Cambridge University Press.

PHYS-6119 **Quantum Mechanics-I** **3(3+0)**

Quantum mechanics is important because it plays a fundamental role in explaining how the world works. Physicists often say quantum mechanics governs the behavior of microscopic systems when in fact it governs the behavior of all physical systems, regardless of their size. Quantum mechanics tells us a lot about the structure of reality. In this course we review the fundamental ideas of quantum mechanics, introduce the path integral for a non-relativistic point particle, and use it to derive time-dependent perturbation theory and the Born series for non-relativistic scattering. The course concludes with an introduction to relativistic quantum mechanics and the ideas of quantum field theory.

Contents

1. wsfcvReview of concepts of classical mechanics
2. Historical review (experiments and theories)
3. Wave aspects of particles
4. Hilbert space and wave functions
5. Mathematical tools of quantum mechanics
6. The linear vector space, the hilbert space, dimensions and basis of a vector space
7. Square integrable wave functions, dirac notation and operators
8. Basic postulates of quantum mechanics
9. The state of a system and observables
10. Measurement in quantum mechanics
11. Time evolution of the system's state
12. Time evolution operator, stationary states
13. Time independent potentials, time evolution of expectation values
14. Symmetries and conservation laws
15. General properties of one dimensional schrödinger equation
16. Symmetric potentials and parity
17. Properties of one dimensional motion
18. Solution of simple one dimensional system: the free particle
19. The step potential and the potential barrier and well
20. The infinite square well potential, the finite square well potential

Recommended Texts

1. Liboff, R. L. (2002). *Introductory quantum mechanics* (4th ed.). New York: Addison Wesley Publishing Company.
2. Zettili, N. (2009). *Quantum mechanics: concepts and applications* (2nd ed.). New York: Wiley.

Suggested Readings

1. Townsend, J. S. (2012). *A modern approach to quantum mechanics* (2nd ed.). New York: University Science Books.
2. Robinett, R. W. (2006). *Quantum mechanics, classical results, modern systems and visualized examples* (2nd ed.). Oxford: Oxford University Press.
3. Gasiorowicz, S. (2003). *Quantum physics* (3rd ed.). New York: Wiley.
4. Griffiths, D. J. (2018). *Introduction to quantum mechanics* (3rd ed.). Cambridge: Cambridge University Press.

PHYS-6120 **Solid State Physics-I** **3(3+0)**

This course mainly provides an introduction to the theory of solid state materials with emphasis on crystalline materials. Their diverse interesting properties can comprehensively be illustrated using some fundamental concepts related to their internal geometries. This course includes a theoretical description of crystal structure and its different geometries, interatomic bonding, detailed investigation of theoretical and experiment concepts of x-ray diffraction, and involvement of lattice dynamics, which give birth to some successful theories of lattice heat capacity of solids based on the principles of classical and quantum physics. The course provides a basis for understanding the scientific literature on novel materials and to further studies in material science and nanotechnology.

Contents

1. Crystal structure in 2D and 3D, fundamental types of lattices
2. Index system for crystal planes, simple crystal structures
3. X-ray diffraction, braggs law
4. Reciprocal lattice, diffraction of waves by crystals
5. Scattered wave amplitude
6. Brillouin zones
7. Crystal binding and elastic constants
8. Classification of solids, ionic crystals, covalent crystals, ionic radii, II-VI and III-V compounds
9. Molecular crystals, metals, cohesive energy
10. The lenard jones potential
11. Density, cohesive energy and bulk modulus of crystalline solids, the madelung constant
12. Vibration of crystals with monatomic and diatomic lattice
13. Quantization of elastic waves, normal vibration modes
14. Phonon, phonon momentum
15. Inelastic scattering by phonons, phonon heat capacity
16. lattice heat capacity, einstein and debye models
17. Sommerfeld model of free electron theory
18. Energy levels in one dimension
19. Free electron gas in three dimension
20. DC and ac electrical conductivity of metals

Recommended Texts

1. Kittle, C. (2005). *Introduction to solid state physics* (8^{th} ed.). New Jersey: Wiley
2. Wahab, M. A. (2017). *Solid states physics: structure and properties of materials* (3^{rd} ed.). Oxford: Alpha Science International.

Suggested Readings

1. Szwachi, N. G. & Szwacka, T. (2016). *Basic elements of crystallography* (2^{nd} ed.). Singapore: Pan Stanford Publishing.
2. Simon, S. H. (2013). *The oxford solid state basics* (1^{st} ed.). Oxford: Oxford University Press.
3. Blakemroe, J. S. (2012). *Solid state physics* (2^{nd} ed.). Cambridge: Cambridge University Press.

PHYS-6115 **Electronics Lab** **3(0+3)**

This course introduces the students to basic of electric circuits through a series of experiments. This includes the working principles of resistors, capacitors and inductors. Students learn different experimental techniques to determine the values of combination of different circuits. The course introduces students to the basic components of electronics: diodes, transistors, and operational amplifiers. It covers the basic operation and some common applications.This laboratory course will help the students in getting familiarized with basic electrical measurement techniques, enhancing ability to apply electrical theory to practical problems, practice in recording and reporting technical information, familiarization with electrical safety requirement and also verification of some basic electric circuit theorems.

Contents

1. To construct from discrete components or, and, not circuits and verify their truth tables
2. To construct from discrete components nand, nor, exclusive or circuits and verify their truth tables
3. Design a fixed and self-bias and voltage divider bias transistor
4. To construct a single stage ce transistor voltage amplifier and study gain, input impedance, output impedance, and half power points by sine/square wave testing and effect of bias on the output and measurement of distortion
5. To construct and study the wave forms at the base and collector of the transistors of a free running a multivibrators
6. To construct and study of the height, duration and time period of the output pulses in a monostable and bistabale multivibrators with reference to the input trigger
7. To study of rc integrators and differentiators
8. Design an inverting and non-investing d.c. Amplifier, measurement of parameters of a given ic operational amplifier
9. Design and study the application of operational amplifier (current to voltage converter, instrumentation amplifier, buffer, voltage clamp, integrator and differentiator. low and high pass filters and half-wave rectifier)
10. To construct a phase shift or wein bridge oscillator and measure its frequency by 741,555 timer

Recommended Texts

1. Robert, L. B. & Nashelsky, L. (2005). *Electronic devices and circuit theory* (9th ed.). New Jersey: Prentice Hall.
2. Higgins, R. J. (1974). *Experimental electronics* (4th ed.). New York: McGraw-Hill Education.

Suggested Readings

1. Mitchel, E. S. (2003). *Grob's basic electronics* (13th ed.). New York: McGraw-Hill Education.
2. Thomas, L. F. (1981). *Principles of electric circuits* (31st ed.). Boston: Charles E. Merrill Publishing Co.

PHYS-6122 Statistical Mechanics 3(3+0)

The course titled Statistical Mechanics is intended for students enrolled for B.S degree in Physics. The purpose of this course is to translate the microscopic world where the laws of nature are written to the everyday macroscopic world that we're familiar with. This will allow us to begin to address very basic questions about how matter behaves. Statistical Mechanics is a probabilistic approach to equilibrium properties of large numbers of degrees of freedom. This course aims to cover both classical and quantum statistical mechanics. It demonstrates the firm physical and statistical basis of thermodynamics by showing how the properties of macroscopic systems are direct consequences of the behaviors of their elementary constituents. We can apply statistical mechanics to solve for real systems (a system for many particles). This course will provide students a broader spectrum of skills as well as a better understanding of the physical bases. They will be able to apply the concepts learnt to everyday problems and systems.

Contents

1. Review of thermodynamics: mathematical formulation of first and second law of thermodynamics
2. Maxwell's relation, reduction of derivatives, general conditions of equilibrium
3. Partition function: partition function, relations of partition function with thermodynamical variables, examples (collection of simple harmonic oscillators, half spin paramagnet)
4. Basic principles of statistical mechanics: microscopic and macroscopic states, phase space, ensemles,liouvillie theorem
5. Formation of microcanonical, canonical and grand canonical partition function, maxwell distribution of molecular speed
6. Probability of the particle in quantum state, density of states in k-space,single particle density of states in energy
7. Maxwell-boltzman distribution function, validity of maxwell-boltzman statistics, evaluation of constants α and β, maxwell speed distribution function
8. Theory of ideal fermi system: fermi-dirac distribution function, examples of the fermi system (free electron theory of metals, electrons in stars, electrons in white dwarf stars)
9. Theory of bose system: bos-einstein distribution function, black body radiation, the photon gas, ideal bose gas model of liquid helium, einstein's model of vibration in a solids, debye's model of vibration in a solids, advanced topics: fluctuations, bose-einstein condensation
10. Introduction to density matrix approach

Recommended Texts

1. Reif, F. (2009). *Fundamentals of statistical and thermal physics*. New York: McGraw Hill.
2. Garg, S. C., Bansal, R.M. & Ghosh, C.K. (2012). *Thermal physics* (2nd ed.). New Delhi: McGraw Hill.

Suggested Readings

1. Agarwal, B. K. & Melvin, E. (2012). *Statistical mechanics* (3rd ed.). New Delhi: New Age International.
2. Pathria, R. K. (2011). *Statistical mechanics*.London: Elsevier Ltd.
3. Sinha, S. K. (2007). *Introduction to statistical mechanics*. Oxford: Alpha Science International.

PHYS-6123 **Atomic Physics** **3(3+0)**

Atomic physics (or atom physics) is a field of physics that involves investigation of the structures of atoms, their energy states, and their interactions with other particles and electromagnetic radiation. In this field of physics, atoms are studied as isolated systems made up of nuclei and electrons. Its primary concern is related to the arrangement of electrons around the nucleus and the processes by which these arrangements change. The aim of this course is to develop an understanding to the physics of atoms, atomic structure. Additionally it covers, the observed dependence of atomic spectral lines on externally applied electric and magnetic fields.

Contents

1. Atomic structure, the thomson model, the rutherford model, alpha-particle scattering, the rutherford scattering formula
2. Electron orbits, sommerfeld model, the bohr model of the atom
3. Atomic spectra of hydrogen atom, the frank-hertz experiments
4. Nuclear motion and reduced mass, the correspondence principle, hydrogenic atom
5. Quantum theory of the hydrogen atom, schrodinger equation for the hydrogen atom, separation of variable
6. Quantum numbers, total quantum numbers, orbital quantum number, magnetic quantum number, angular momentum
7. The normal zeeman effect, electron probability density
8. Many electrons atoms, electron spin, the stern-gerlach experiments, spin-orbit interaction, exclusion principle
9. Electron configuration in many electron-atoms, hund's rules
10. Coupling of angular momenta, coupling schemes, ls-coupling, jj-coupling
11. Origin of spectral lines, selection rules
12. One electron spectra, two-electron spectra
13. Relative intensities in a multiple
14. X-ray spectra
15. Atoms in magnetic and electric fields
16. Space quantization , magnetic moment and bohr magneton
17. Paschen-back effect, stark effect

Recommended Texts

1. Foot, C. (2005). *Atomic physics* (1st ed.). New York: Oxford University Press.
2. Brandsen, B. H., Joachian, C. J. & Plivier, T. J. (2003). *Physics of atoms and molecules* (2nd ed.). London: Person Education.

Suggested Readings

1. Krane, K. S. (2019). *Modern physics* (4th ed.). New York: John Wiley & Sons.
2. White, H. E. (2016). *Introduction to atomic spectra* (1st ed.). New Delhi: McGraw-Hill.
3. Haken, H. & Wolf, H. C. (2012). *The physics of atoms and quanta: Introduction to experiments and theory*. Berlin: Springer.

PHYS-6124 Plasma Physics 3(3+0)

This is a calculus-based introductory course on plasma physics with maximum emphasis on conceptual understanding, mathematical formulation, interpretation of the fundamental principles of plasma physics and application of the acquired knowledge for solving problems. In this course, students will learn about plasmas, the fourth state of matter. The plasma state dominates the visible universe, and is of increasing economic importance. Plasmas behave in lots of interesting and sometimes unexpected ways. The aim of this course is to describe, in words, the ways in which various concepts in plasma physics come into play in particular situations and discuss the applications and properties of human-made and naturally occurring plasmas. This course provides the students the up-to-date treatment of classical mechanical systems and serves as basics and pre-requisite of Quantum Mechanics so that students face least difficulty in entering from classical Physics to Quantum mechanics.

Contents

1. Occurrence of plasma in nature, definition of plasma, concept of temperature
2. Debye shielding, plasma parameter, criteria for plasma
3. Applications of plasma physics
4. Single-particle motion in uniform E and B fields, single-particle motion in nonuniform B field, single-particle motion in nonuniform E field
5. Time varying E field, time varying B field, adiabatic invariants
6. Fluid description of plasma
7. Fluid equation of motion
8. Fluid drift perpendicular to B, fluid drift parallel to B, the plasma approximation
9. Representation of waves, group velocity
10. Plasma oscillations
11. Electron plasma waves
12. Sound waves, ion waves, validity of plasma approximation
13. Comparison of electron and ion waves
14. Electrostatic electron oscillations perpendicular to B

Recommended Texts

1. Chen, F. F. (2016). *Introduction to plasma physics and controlled fusion* (3rd ed.). New York: Springer.
2. Bittencourt, J. A. (2004). *Fundamentals of plasma physics* (3rd ed.). New York: Springer.

Suggested Readings

1. Bellan, P. M. (2006). *Fundamentals of plasma physics* (1st ed.). Cambridge: Cambridge University Press.
2. Goldston, R. J. (2019). *Introduction to plasma physics*. Bristol: IOP Publishing.
3. Dendy, R. O. (1993). *Plasma physics: an introductory course.* Cambridge: Cambridge University Press.

PHYS-6125 Quantum Mechanics-II 3(3+0)

Quantum physics is arguably the greatest intellectual triumph in the history of human civilization, but to most people it seems like it's too remote and abstract to matter. This is largely a self-inflicted wound on the part of physicists and pop-science writers: when we talk about quantum physics, we usually emphasize the weird and counter-intuitive phenomena but it can be hard to see any connection between these phenomena and everyday life. This course examines the fundamental concepts and techniques of quantum mechanics. Students will develop a self-critical perspective on the theoretical techniques to solve the problems. Rather the task is to develop reflective and critical skills for thinking about creative solutions to for further higher studies and applications.

Contents

1. Orbital angular momentum
2. The eigenvalues and eigen-functions of l^2 and $l_{z.}$
3. Matrix representation of angular momentum operators
4. Addition of angular momenta
5. Schrödinger equation in three dimensions
6. 3d problems in cartesian and spherical coordinates
7. Approximate methods
8. Time independent perturbation theory for non degenerate and degenerate levels
9. The variational method
10. The wkb approximation and time dependent perturbation theory
11. Identical particles and second quantization
12. Many particles systems and systems of identical particles
13. The pauli exclusion principle, theory of scattering
14. The interaction of quantum systems with radiation
15. Classical treatment of incident radiation
16. Quantization of the electromagnetic field
17. Transition rates for absorption, emission of radiation
18. Transition rates within the dipole, the electric dipole selection rules

Recommended Texts

1. Liboff, R. L. (2002). *Introductory quantum mechanics* (4th ed.). New York: Addison Wesley Publishing Company.
2. Zettili, N. (2009). *Quantum mechanics: concepts and applications* (2nd ed.). New York: John Wiley & Sons.

Suggested Readings

1. Townsend, J. S. (2012). *A modern approach to quantum mechanics* (2nd ed.). New York: University Science Books.
2. Robinett, R. W. (2006). *Quantum mechanics, classical results, modern systems and visualized examples* (2nd ed.). Oxford: Oxford University Press.
3. Gasiorowicz, S. (2003). *Quantum physics* (3rd ed.). New York: Wiley.
4. Griffiths, D. J. (2018). *Introduction to quantum mechanics* (3rd ed.). Cambridge: Cambridge University Press.

PHYS-6126 **Solid State Physics-II** **3(3+0)**

This course is organized in a logical sequence to ensure the utilization of the basic concepts of solid state physics, quantum mechanics, and the crystallography of solids to elaborate their unique properties. Some theoretical aspects which allow us to treat the complex behavior of charge carriers in solids are discussed. Also included, some extended introductions to electronic band structure models, the motion of electrons in energy bands are dealt with simple phenomena encountered in solids. One of the most important phenomena involved in the response of charge carriers under the influence of external fields. Then, the properties of semiconductors will be discussed. Later on, after exploring the origin of magnetism, we put our focus towards the optical properties of solids. Finally, the theoretical and experimental concepts of superconductivity will be discussed in details.

Contents

1. Solid state problem, free electron approximation, density of states
2. Fermi dirac distribution, k-space
3. Concept of fermi energy and the fermi surface
4. Free electron description of heat capacity
5. Electrical conductivity of metals, hall effect
6. Nearly free electron model, origin of the energy gap
7. Bloch functions, concept of hole
8. Periodic & extended zone schemes, motion of electrons in a periodic potential
9. Crystal momentum, effective mass, physical interpretation of the effective mass
10. Kronig-penney model, calculation of band structure
11. tight-binding method
12. Intrinsic carrier concentration, mobility, impurity conductivity donor states, acceptor states
13. Thermal ionization of donors and acceptors
14. Simple description of pn-junction and rectification
15. Transistors, semiconductors heterostructures and outline of solid state lasers
16. Optical properties of solids
17. Diamagnetism and paramagnetism, larmor diamagnetism, pauli paramagnetism, conduction electrons diamagnetism
18. Introduction to superconductivity and its types, transition temperature, messiner effect
19. Cooper pair, bcs theory, Josephson effects, applications

Recommended Texts

1. Pillai, S.O. (2005). *Solid states physics* (6th ed.). New Delhi: New age international limited.
2. Wahab, M. A. (2017). *Solid states physics: structure and properties of materials* (3rd ed.). Oxford: Alpha Science International.

Suggested Readings

1. Ibach, H. & Lüth, H. (2009). *Solid states physics* (4th ed.). New York City: Springer.
2. Ashcroft, N. W. & Mermin, N. D. (2003). *Solid state physics* (1st ed.). Hong Kong: CBS Publishing Asia.
3. H. P. Myers. (2002). *Introductory solid states physics* (2nd ed.). Boca Raton: CRC Press.

PHYS-6127 Computational Physics 3(3+0)

Computational Physics is consisted of techniques to approximate mathematical procedures (e.g., integrals). Approximations are needed because we either cannot solve the procedure analytically (e.g., the standard normal cumulative distribution function) or because the analytical method is intractable (e.g., solving a set of a thousand simultaneous linear equations for a thousand unknowns). By end of this course, participants will be able to apply the Computational Physics for the following mathematical procedures and topics: differentiation, nonlinear equations, and simultaneous linear equations, interpolation, regression, integration, and ordinary differential equations. Additionally, they will be able to calculate errors and implement their relationship to the accuracy of the numerical solutions.

Contents

1. Basics of numerical computation
2. Principles of computer operations
3. Roots of equations (real roots by iterative method, newton raphson method, regulafalsi method bisection method)
4. Computing cardinals: numerical integration (trapezoidal method, simpson’s method and gauss quadrature method)
5. Numerical solutions of odes (euler’s method, modified euler’s method, rk4 method)
6. Interpolation and extrapolation (finite difference, newton forward difference method, newton backward difference method, difference operators
7. Linear interpolation, interpolating polynomials, the lagrange interpolating polynomial) starting with malab
8. Creating arrays and mathematical
9. Operations with arrays using script files and managing data
10. Implementation of numerical analysis in matlab
11. Two dimensional and three dimensional plots
12. User defined functions and function files
13. Symbolic math
14. Modelling and simulations
15. Case study

Recommended Texts

1. Peter, A. S. (1992). *Introduction to numerical methods* (2nd ed.). London: Macmillan Publications Ltd.
2. Amos, G. (2011). *MATLAB® An introduction with applications* (4th ed.). New York: Wiley.

Suggested Readings

1. Pinter, C. & Dejong, M. (1991). *Introduction to computational physics* (2nd ed.). Massachusetts: Addison-Wesley
2. Macheown, P. K. & Merman, D. J. (1987). *Computational techniques in physics* (4th ed.). Bristol: AdmHilger.

PHYS-6128 **Laser Physics** **3(3+0)**

In this course the students will get a basic understanding of the physics of lasers, their unique properties and potential for applications in optical spectroscopy, material processing, 3-D imaging, chemistry, medicine, optical communications, biomedicine, defense industries, etc. The course provides the students physical foundations for lasers, including light-matter interaction phenomena (absorption, emission and dispersion), propagation of laser beams, laser resonators, rate equations for lasers, transient laser phenomena, principles and characteristics of cw and pulsed lasers, and some topical laser applications as a case study. The course will also treat some common types of laser in more detail, including continuous-wave (cw) and pulsed, gas and solid state lasers. At the end some laser applications will be discussed.

Contents

1. Introduction to lasers, properties of laser beam, electromagnetic waves and photons
2. Energy levels, transition and spectral lines, the metastable level, spontaneous and stimulated emission, stimulated absorption
3. Line shape function, black-body radiation, relation between einstein *a* and *b* coefficients
4. Conditions for large stimulated emissions, gain coefficient and threshold gain coefficient
5. Line-broadening mechanism
6. Population inversion, the three and four-level system
7. Rate equations for two-level, three-level and four-level systems
8. Optical resonators, conditions for steady state oscillation in a two mirror resonator, cavity resonance frequencies
9. Longitudinal and transverse modes in a cavity
10. Pumping process, pulsed vs continuous emission
11. Threshold condition and output power, optimum output coupling, laser tuning
12. Oscillation and pulsations in lasers, q-switching and mode-locking methods
13. Phase velocity and group velocity
14. Dispersion and pulse width, non-linear crystals
15. Solid state lasers: ruby laser and nd:yag lasers
16. Semiconductor lasers: homojunction lasers, double hetrojunction lasers
17. Gass lasers: helium neon laser, co_2 laser, nitrogen laser and excimer laser
18. Free-electron and x-ray lasers, and laser applications

Recommended Texts

1. Silfvast, W. T. (2008). *Laser fundamentals.* New York: Cambridge University Press.
2. Milonni, P. W. & Eberly, J. (2010). *Laser physics.* New Jersey: John Wiley & Sons, Inc.

Suggested Readings

1. Hecht, J. (2018). *Understanding lasers*. New Jersey: Wiley-IEEE Press.
2. Hooker, S. & Webb, C. (2010). *Laser physics*. Oxford: Oxford University Press.
3. Svelto, O. (2010). *Principles of lasers*. New York: Springer.
4. Haken, H. (2012). *Laser theory*. Heidelberg: Springer.
5. Avadhanulu, M. N. & Hemne, P. S. (2001). *An Introduction to lasers-theory and applications*. New Delhi: S. Chand Publishing.

PHYS-6129 Relativity and Cosmology 3(3+0)

In this course, students will be introduced to the field of relativistic physics, learning about its history and its modern branches of study. This course provides students an insight of the principles of special theory of relativity and general theory of relativity and some of their main observational consequences (relativistic kinematics, higher dimensional space-time, cosmology, black holes and others). A student studying the course of Relativity and Cosmology will understand classical as well modern physics and will also acquire the skills to apply principles to new and unfamiliar problems. With this self-paced course, students get engaging lessons, expert instructors who make even the most challenging physics topics simple, and an excellent resource for getting a head start on student's physics graduate degree.

Contents

1. Galilean transformation, existence of ether,
2. Michelson-morley experiment, stellar aberration
3. Einstein's postulates of special relativity
4. Lorentz transformations
5. Relativity of simultaneity
6. Ttime dilation (twins paradox)
7. Length contraction (ladder paradox)
8. Velocity transformation and velocity addition
9. Relativistic mechanics
10. Minkowski spacetime, line element
11. Four-vectors, force equation in relativity
12. Rest mass, kinetic and total energy
13. Conservation of energy and momentum
14. Elements of tensor calculus, manifolds and coordinates, curves and surfaces
15. Tensor fields, lie derivative
16. Geodesics, parallel transport
17. Riemann tensor, metric tensor, christoffel symbols
18. General relativity, principles of general relativity
19. Equation of geodesics, einstein's field equations
20. Cosmology, newtonian cosmology, cosmological redshift
21. Hubble's law, the big bang, expansion rate

Recommended Texts

1. Cheng, T. (2015). *A college course on relativity and cosmology* (1st ed.). Oxford: Oxford University Press.
2. Forshaw, J. R. & Smith, A. G. (2009). *Dynamics and relativity* (1st ed.). New York: Wiley.

Suggested Readings

1. McMohan, D. (2006). *Relativity demystified* (1st ed.). New York: Mc Graw-Hill.
2. McComb, W. D. (1999). *Dynamics and relativity* (2nd ed.). Oxford: Oxford University Press.
3. Narlikar, J. V. (2002). *Introduction to cosmology* (3rd ed.). Cambridge: Cambridge University Press.

PHYS-6130 Nuclear and Elementary Particle Physics 3(3+0)

In Nuclear physics we study about atomic nuclei, their constituents and interactions. Other forms of nuclear matter are also studied. Nuclear physics should not be confused with atomic Physics, which studies the atom as a whole, including its electrons. Particle Physics evolved out of nuclear physics.In nuclear physics we study about introduction of nucleus, accelerators, different types of detectors, different types of nuclear forces and their interactions and about particle physics. The aim of this course is use their conceptual understanding of the Properties of Nucleus, use their ability to manage and operate different kind of detectors, have the knowledge about the particle accelerator and can use it to work on this machine for advance research, apply this knowledge in practical situations.

Contents

1. Basic properties of nucleus: size and mass of the nucleus
2. Nuclear spin, magnetic dipole moment
3. Eelectric quadropole moment
4. Parity and statistics, detectors, passage of charged particle through matter, ionization chamber, proportional counter, scintillation counter
5. Semi-conductor detector, emulsion technique, bubble chamber
6. Particle accelerators: linear accelerator, van de graff, betatron, synchrocyclotron, proton synchrotron
7. Nuclear forces, yukawa theory, proton-proton and neutron-proton scattering, charge independence of nuclear force, isotopic spin
8. Liquid drop model, shell model, collective model, conservation laws of nuclear reaction, q-value of nuclear reaction
9. Threshold energy, transmutation by photons, proton, deuterons and alpha particles, excited states of nucleus, energy levels, level width, cross section from nuclear reactions
10. Breit-wigner formula, direct reactions
11. Theory of fission and spontaneous fission
12. Nuclear chain reaction and applications, thermonuclear reactions, fusion and thermonuclear process
13. Energy released in nuclear fusion, formation of heavy elements
14. Semi-carbon nitrogen cycle controlled nuclear fusio
15. Introduction, fundamental interactions, classification of elementary particles, parameters of elementary particles, the mass less bosons
16. The leptons, the mesons, the baryons, the eight fold way, quarks, color, charm

Recommended Texts

1. Wong, S. M. (2004). *Introductory nuclear physics* (2^{nd} ed.). Weinheim: Wiley
2. Chatwa, G. (2007). *Nuclear physics* (2^{nd} ed.). New Delhi: Dominant Publisher and Distribution.

Suggested Readings

1. Wiedemann, H. (2007). *Particle accelerator physics* (2^{nd} ed.). Berlin: Springer.
2. Krane, S. (1987). *Introductory nuclear physics* (3^{rd} ed.). New Jersey: Wiley.
3. Bernardeau, F., Grojean, C. & Dalibard, J. (2007). *Particle physics and cosmology*. Amsterdam: Elsevier Science.

PHYS-6131 Advanced Electronics 3(3+0)

Advance Electronics is the course of zero and one. This course includes the theoretical and practical approach for designing of computer. This course starts with number system and their interconversions which is the basic for designing of a digital system. The course also contains different types of logic circuits, i.e. combinational logic and sequential logic circuits. The different types of counter and register circuits are designed. The basic architecture of microprocessor and microcontroller is discussed and the concepts of RAM and ROM along with designing are given. After this course the students will be able to design the small or large digital circuits. They will also be able to study the logic gates and implementation of Boolean functions using different logic families.

Contents

1. Number systems and operations (number systems their introversion)
2. Codes (bcd, excess-3, gray) error detection and correction codes, parity codes, and 7-segment display code logic
3. Gates and related devices
4. Logic families- significance and types
5. Boolean algebra and simplification techniques
6. Combinational logic design, and flip-flops
7. Sequential logic circuits (registers and application of shift register), ripple counters, synchronous counter
8. Microprocessors, introduction to microprocessors, inside a microprocessor, and arithmetic logic unit (alu)
9. Processor family, intel microprocessor hierarchy
10. Microcontrollers, introduction to the microcontroller, applications, inside the microcontroller
11. Central processing unit (cpu)
12. Random access memory (ram), read only memory (rom)
13. Special-function registers
14. Peripheral components
15. Microcontroller architecture, architecture to access memory, and 8-bit microcontrollers

Recommended Texts

1. Mano, M. M. (2017). *Digital logic and computer design* (5th ed.). New Delhi: Pearson.
2. Tokheim, R. L. (2013). *Digital electronics: principles and applications* (8th ed.). Boston: MacGraw-Hill education.

Suggested Readings

1. Floyd, T. L. (2014). *Digital fundamentals* (11th ed.). New Jersey: Prentice Hall, Pearson.
2. Morris, M., Michael, M. & Ciletti, D. (2013). *Digital design* (5th ed.). Upper Saddle River: Prentice Hall, Pearson.
3. Kumar, A. A. (2016). *Fundamentals of digital circuits* (4th ed.). New Delhi: PHI Learning.
4. Boylestad, R. & Nashelsky, L. (2002). *Electronic devices and circuit theory*. New Jersey: Pearson Prentice Hall.

PHYS-6132 **Physical and Geometrical Optics** **3(3+0)**

Optics is a branch of physics that deals with the determination of behavior and the properties of light, along with its interactions with the matter and also with the instruments which are used to detect it. There are two major branches of optics, physical and geometrical. Physical optics deals primarily with the nature and properties of light itself. Geometrical optics has to do with the principles that govern the image-forming properties of lenses, mirrors, and other devices that make use of light. This course is designed to help students gain an understanding of the fundamental principles of optics and photonics. It is primarily a theoretical course with some application to optical design. The course focuses on physical optics including the Fresnel Laws of refraction and reflection, interference, Fourier analysis and diffraction. This course also covers the basic concepts of geometrical ray optics and aberrated imaging needed in further optician education and professional work.

Contents

1. Light - a historical perspective
2. Production and measurement of light: electromagnetic spectrum, black body radiations, source of radiations, detectors of radiation
3. Huygens' principal, fermats' principle, reflection in plane mirror, reflection through plane surfaces, imaging by an optical system, thin lenses
4. The thick lens, the ray tracing
5. Cylindrical lenses, combining cylindrical powers, astigmatism
6. Ray and wave aberrations, spherical and chromatic aberration, aberrations in vision
7. Controlling light through optical system: controlling image brightness and field of view
8. Optical instruments: prisms, camera, magnifiers and eyepieces, microscopes, telescopes
9. Light as waves: harmonic waves, electromagnetic waves, doppler effect, superposition principle, standing waves
10. Interference phenomena: two-beam interference, young's double slit experiment, interference in dielectric films
11. Interference applications: newton's rings, film thickness measurement by interference, the michelson interferometer, holography
12. Polarized light: modes of polarization, polarizing elements
13. Fraunhofer diffraction: diffraction from a single slit, rectangular and circular apertures, resolution, multiple slit diffraction
14. Fiber optics: optics of propagation, sources and detectors

Recommended Texts

1. Pedrotti, F. L., Pedrotti, L. S. & Pedrotti, L.M. (2008). *Introduction to optics* (3rd ed.). New Delhi: Pearson Education.
2. Eugene, H. & Ganesan, A. R. (2012). *Optics* (4th ed.). New Delhi: Pearson Education.

Suggested Readings

1. Garbovskiy, Y. A. & Glushchenko, A. V. (2017). *A practical guide to experimental geometrical optics*. New York: Cambridge University Press.
2. Freenan, M. H. & Hull, C. C. (2013). *Optics* (11th ed.). Berlin: Elsevier.
3. Sharma, K. K. (2006). *Optics: principles and applications.* New Jersey: Elsevier.

PHYS-6133 Physics of Nanotechnologies 3(3+0)

This course introduces the concepts of nanomaterials and their types, importance of nanometer scale and origins of nanoscopic behaviour along with some applications from different fields e.g, industry, agriculture, medicine etc. Secondly it elaborates different techniques of fabrication of nanomaterials using different top down and bottom up approaches e.g, different lithography techniques and wet chemical methods as well as how to study their different properties e.g, surface, structural, physical and chemical properties etc. At the end of this course students will be able to know why we need nanotechnology, what are its applications, what are the challenges for this technology regarding productions of nanomaterials and nanodevices.

Contents

1. Introduction to nano physics
2. Importance, types of nanomaterials and their applications
3. Origin of observed differences between nanoscopic and macroscopic materials
4. Carbon based nanomaterials
5. Graphene: properties and application of graphene, electrical & thermal conductivity, mechanical strength, elasticity, optical properties
6. Carbon nanotubes: properties and applications of carbon nanotubes, electrical & thermal conductivity, mechanical strength, elasticity, optical properties
7. Thin film deposition techniques
8. Physical vapour deposition techniques: pulsed laser deposition, sputtering, molecular beam epitaxy, electron beam evaporation
9. Chemical vapour deposition techniques: chemical vapour deposition
10. Nanofabrication techniques
11. Top down nanofabrication techniques: optical lithography, e-beam lithography, nano-imprint lithography
12. Bottom up nanofabrication techniques: chemical reduction, hydrothermal, co-precipitation methods
13. Nanostructures characterization techniques: surface and structural characterization
14. Surface analysis: scanning electron microscopy, transmission electron microscopy, atomic force microscopy, scanning tunneling microscopy
15. Structural analysis: x-ray diffraction

Recommended Texts

1. Wolf, E. L. (2015). *Nanophysics and nanotechnology: An introduction to modern concepts in nanoscience*. New York: John Wiley & Sons.
2. Chrisey, D. B. & Hubler, G. K. (1994). *Pulsed laser deposition of thin films*. New York: Wiley-Interscience

Suggested Readings

1. Wiesendanger, R. (2013). *Scanning probe microscopy: Analytical methods*. New York: Springer Science & Business Media.
2. Goldstein, J. I., Newbury, D. E., Michael, J. R., Ritchie, N. W., Scott, J. H. & Joy, D. C. (2017). *Scanning electron microscopy and x-ray micro analysis.* New York: Springer.

PHYS-6134 **Methods of Experimental Physics** **3(3+0)**

The main objective of this course is to give students a brief introduction of some important experimental techniques related to experimental research in physics which are currently being used in different modern research labs e.g, vacuum technology to make contamination free samples at nanoscale and different type of sensors to measure different physical parameters e.g, pressure, temperature, magnetic field etc. Vacuum technology includes concepts of fundamental vacuum physics, importance, applications, ranges creation and measurement of vacuum, hurdles regarding creation of vacuum and mathematical modeling of fluid dynamics and pumping process. This course also provides a comprehensive introduction to construction and working of different vacuum related devices and different types of sensors.

Contents

1. Introduction to vacuum physics: importance, ranges and applications of vacuum
2. Molecular description of gases: kinetic molecular theory of gases, continuum and molecular states of gases, mean free path, molecular number density, impingement rate
3. Surfaces processes: scattering of a molecule from a surface, adsorption and desorption processes and their mathematical modeling
4. Outgassing: origins, importance and mathematical modeling of outgassing rate due to different sources e.g, desorption, diffusion & permeation
5. Sputtering: mechanism, factors affecting sputtering yield, applications of sputtreing
6. Gas flow: continuum and molecular flow of gases
7. Conductance and pumping speed, mathematical modeling for conductance of long, short pipe and an aperture both for continuum and molecular flow regimes
8. Pumping process, pump down time and ultimate pressure
9. Vacuum pumps: rotary & root pumps, turbo molecular pump, ionic and titanium sublimation pumps
10. Vacuum gauges: diaphragm & capacitance diaphragm guages, spin rotor, penning & magnetron gauges
11. Sensor technology: temperature sensors, optical sensors, magnetic sensors, fluid flow sensors, metal detectors

Recommende Texts

1. Chambers, A. (2004). *Modern vacuum physics* (1st ed.). London: CRC Press.
2. Fraden, J. (2010). *A handbook of modern sensors: Physics, design and applications (4th ed.)*. New York: Springer.

Suggested Readings

1. Hoffman, D. M. Thomas, J. H. & Singh, B. (1997). *Handbook of vacuum science and technology.* London: Elsevier.
2. Yoshimura, N. (2007). Vacuum *technology: Practice for scientific instruments*. New York: Springer.
3. Martin, L., Weissler, G.L. & Carlson, R. W. (1979). *Methods of experimental physic: Vacuum physics and technology.* New York: Springer

PHYS-6135 **Advanced Electronics LAB** **3(3+0)**

This lab is the practical approach of theoretical concepts of “Advanced Electronics” already studied in pervious semester. The designing of different circuits is done and verified by using the truth tables. The clock pulse is also designed and studies the operation of different types of counter. This lab provides the students with a broad understanding of theory of advance electronic by the implementation to empower them to think creatively and critically about scientific problems and experiments (thought as well real-life). After this lab, the students will be able to design any circuit from it’s logic diagram. They will also be able to understand the design and working of consumer/industrial electronics, communications, embedded systems, microprocessors, and security equipments widely used in everyday life. This laboratory course will help the students in getting familiarized with basic electrical measurement techniques, enhancing ability to apply electrical theory to practical problems, practice in recording and reporting technical information, familiarization with electrical safety requirement.

Contents

1. Implementation of logic using different logic families
2. Using ic’s construct and study rs, jk (master slave), t, and d flip-flops
3. Design and study of a half and full adder with different boolean expression using ic’s
4. Design and study different combinational circuit(bcd adder,7-segment decoder, comparator encoder, multiplexer circuits)
5. To study combinational lock and led sequencer circuits
6. Synchronous and asynchronous bcd counters, memory shift register with ic’s
7. Design and study of decoder, encoder, multiplexer circuits
8. Design and study the 4-bit odd and even parity circuits

Recommended Texts

1. Floyd, T. L. (2014). *Digital fundamental* (11th ed.). New Jersey: Prentice Hall, Pearson.
2. Mono, M. M. & Ciletti, M. D. (2013). *Digital design* (5th ed.). Upper Saddle River: Prentice Hall, Pearson.

Suggested Readings

1. Mono, M. M. (2017). *Digital logic and computer design* (5th ed.). New Delhi: Pearson.
2. Tokheim, R. L. (2013). *Digital electronics: principles and applications* (8th ed.). Boston: MacGraw-Hill Education.
3. Kumar, A. A. (2016). *Fundamentals of digital circuits,* (4th ed.). New Delhi: PHI Learning.
4. Robert, L. B. & Nashelsky, L. (2005). *Electronic devices and circuit theory* (9th ed.). New Jersey: Prentice Hall.
5. Mitchel, E. S. (2003). *Grob's basic electronics* (13th ed.). New York: McGraw-Hill Education.

PHYS-6136 Introduction to Quantum Computing 3(3+0)

Quantum computing is the use of quantum mechanical phenomena to perform computation and the computers performing quantum computations are known as quantum computers. These computers are supposed to perform much better than their contemporary counterparts. Quantum computation is a subfield of quantum information science. Quantum computing is the major impetus to the development of new general quantum technologies. This course offers a comprehensive introduction to quantum computing. The main objectives of this introductory course is to introduce the background material in mathematics and physics necessary to understand quantum computation and to develop in detail the central results of quantum computation.

Contents

1. Computer technology and historical background
2. Basic principles and postulates of quantum mechanics: quantum states, evolution, quantum measurement, superposition, quantization from bits to qubits, operator function, density matrix, schrodinger equation
3. Schmidt decomposition, epr and bell’s inequality
4. Quantum computation: quantum circuits
5. Single qubit operation
6. Controlled operations
7. Measurement
8. Universal quantum gates, single qubit and cnot gates
9. Breaking unbreakable codes: code making
10. Trapdoor function, one time pad, rsa cryptography
11. Code breaking on classical and quantum computers, schor’s algorithm
12. Quantum cryptography: uncertainty principle
13. Polarization and spin basis, bb84, bb90, and ekert protocols
14. Quantum cryptography with and without eavesdropping
15. Experimental realization
16. Quantum search algorithm

Recommended Texts

1. Nielson, M. A. & Chuang, I. L. (2000). *Quantum computation and quantum information* (2nd ed.). Cambridge: Cambridge University Press.
2. McMahon, D. (2007). *Quantum computing explained* (1st ed.). New York: John Wiley & Sons.

Suggested Readings

1. Bouwmester, P., Ekert, A. & Zeilinger, A. (2000). *The physics of quantum information: quantum cryptography, quantum teleportation, quantum computation*. Berlin: Springer Verlag.
2. Williams, C.P. (2011). *Exploration in quantum computation* (2nd ed.). Berlin: Springer Verlag.
3. Brylinsky, A. K. & Chen, G. (2002). *Mathematics of quantum computation*. London: Chapman & Hall/CRC.

PHYS-6137 Particle Physics 3(3+0)

Particle physics has revolutionized the way we look at the universe. Along the way, it's made significant impacts on other fields of science, improved daily life for people around the world and trained a new generation of scientists and computing professionals.Because particle physics asks big questions—the biggest in all of science, we need new, unique and often very large equipment.Each year, tens of millions of patients receive X-ray, proton and ion therapy to treat cancer at more than ten thousand hospitals and medical facilities around the world. The aim of this course is ofcourse;enable particle physicists to learn about the universe around us. Over the past half century, particle physicists have formulated the Standard Model, a beautiful framework that explains the visible universe from the smallest to the largest scales.

Contents

1. Particle classification, quantum numbers
2. Leptons, hadrons, baryons, mesons, quarks
3. The fundamental interactions
4. The electromagnetic coupling, the strong coupling
5. The weak coupling
6. Symmetry transformation and conservation laws
7. Translation in space, rotation in space
8. The group su (2), systems of identical particles, parity, iso-spin charge conjugation, time reversal
9. G parity, cpt theorem, the electromagnetic field, gauge invariance
10. Maxwell's equations, polarization ad photon spin
11. Angular momentum, parity and c parity of photon
12. Hadron spectroscopy, formation experiment, partial wave formalism and the optical theorem
13. The breit-wigner resonance formula, baryon resonances, phase space considerations
14. Production experiments, the quark model, the group su (3)
15. Quarks, hadrons baryons, mesons in quark model, heave meson spectroscopy
16. The quarkonium model
17. The standard model (qualitative treatment only)
18. Unification of weak and electromagnetic interactions
19. Glashow-salam-weinberg model

Recommended Texts

1. Griffiths, D. (2008). *Introduction to elementary particles* (2nd ed.). Weinheim: Wiley
2. Riazuddin, Fayyazuddin (2012). *Quantum mechanics* (2nd ed.). Singapore: World Scientific.

Suggested Readings

1. Povh, B. Rith, K. & Scholz, C. (2006). *Particles and nuclei: an introduction to the physical concepts*(5th ed.). Berlin: Springer.
2. Bjorken, J. D. & Drell, S.D. (1998). *Relatvistic quantum mechanics* (1st ed.). New York: McGraw Hill.
3. Halzen, F. & Martin, A. D. (1984). *Quarks and leptons* (1st ed.). New Jersey: Wiley.

MPhil
PHYSICS

PHYS-7101 Methods of Mathematical Physics 3(3+0)

Mathematical techniques are important in solving and understanding the physical problems. So the course will provide to demonstrate utility of advanced mathematical techniques in solving problems of physics. How the mathematics is applied to real-world physics problems and also summarize the previous knowledge. This course will provide opportunities for the student to develop skill in the use of the mathematical concepts and also show a wide variety of contexts in which the mathematics is of practical use in physics. It will develop working knowledge of Mathematical Physics at graduate level. This course provides the students the up-to-date treatment of classical mechanical systems and serves as basics and pre-requisite of Quantum Mechanics so that students face least difficulty in entering from classical Physics to Quantum mechanics.

Contents

1. Partial differential equations
2. Approximate solutions of ordinary differential equations
3. Power series and frobenius series, picard iterative method
4. Perturbation series, normal forms, and the wkb approximation
5. The liovelle-green technique, differential equations and green's functions
6. Diffusion equation, heat equations, and wave equations
7. Some nonlinear equations, klein-gordon equation and sine-gordon equation burgers equation
8. Kortweg de vries equation
9. Backlund transformation and differential geometric methods in physics
10. Differentiable manifold and tangent vector
11. I-form or co-vectors and tensor
12. Vector fields, differential forms and exterior derivative
13. Hodge star operator and laplacian hodge decomposition theorem homology group
14. Simplical complexes and p-chain group
15. Singular homology group and stokes theorem

Recommended Texts

1. Arfken, G. B., Weber H. J. & Harris, F. E. (2012). *Mathematical methods for physicists* (7th ed.). Massachusetts: Academic Press.
2. Zill, D. G. (2018). *Advanced engineering mathematics* (6th ed.). Burlington: Jones & Bartlett Learning.

Suggested Readings

1. Chow, T. L. (2000). *Mathematical methods for physicists*: a concise introduction (1st ed.). Cambridge: Cambridge University Press.
2. Petrini, M., Pradisi, G. & Zaffaroni, A. (2017). *A guide to mathematical methods for physicists w*orld scientific (2nd ed.). Singapore: World Scientific Publishing.
3. Dennery, P. & Krzywicki, A. (2012). *Mathematics for physicists* (2nd ed.). New York: Dover Publications.
4. Riley, K. F., Hobson, M. P. & Bence, S. J. (2006). *Mathematical methods for physics and engineering* (3rd ed.). Cambridge: Cambridge University Press.

PHYS-7102 Methods and Techniques of Experimental Physics 3(3+0)

The main objective of this course is give students brief introduction of techniques used in modern research laboratories. In thin film physics, students may learn surface preparation methods, deposition procedures and their characterization. Particularly, in solid state physics, XRD is one of the leading methods worldwide for structural analysis of single crystals and that of polycrystalline materials. In vacuum physics, students learn advanced vacuum generation in experimental instruments in labs. Data analysis and error calculations is a central key in experiments. At the end of this course students will be able to know why we need to learn about instruments and their basic principles of operation, what are their applications, what the challenges are for the technology.

Contents

1. Basics of x-ray diffraction
2. X-ray spectra
3. Bragg's law and importance
4. Construction and operation of diffractometer
5. Data analysis
6. Qualitative (hannawalt method)
7. Quantitative (matrix flushing methods)
8. Vacuum techniques
9. Production of vacuum (vacuum pumps)
10. Measurements of vacuum (gauges)
11. Leak detection
12. Thin film Physics
13. Methods of preparation of thin films
14. Methods of thickness measurement
15. Characterization techniques
16. Basics of spectroscopy and importance
17. Lambert-beer's law
18. Construction and operation of spectrophotometer
19. Radiation detection (detectors)
20. Data analysis
21. Error theory

Recommended Texts

1. Martin, P. M. (2010). *Handbook of deposition technologies for films and coatings* (3rd ed.). Oxford: Elsevier.
2. Wrolfson, R. & Pasachoff, J. M. (1999). *Physics for scientists and engineers.* Boston: Addison Wesley.

Suggested Readings

1. Cullity, B. D. (1978). *Elements of x-ray diffraction*. Boston: Addison-Wesley.
2. Williams, D. (2002). *Methods of experimental physics: spectroscopy.* Massachusetts: Academic Press.

PHYS-7103 **Condensed Matter Physics** **3(3+0)**

This course presumes a working knowledge of quantum mechanics, statistical mechanics, and solid state Physics. It provides an introduction to some basic concepts of solid state. So, in this course not only the concepts about the effective masses of electrons in band theory are discussed but also about quasicrystals, dynamics of phase separation, and the quantum Hall effect will be entertained. Here, we discuss in detail the different advanced methods of band structure determination and also will explore the physical concepts involved behind them. The transport properties of electrons are treated with the help of the Boltzmann transport equation. Particularly, the response of solids in the presence of external fields are considered. Finally, we will treat the qualitative and quantitative basis of BCS theory, Ginzburg-Landua theory and their advance applications.

Contents

1. Electronic structure of solids
2. Independent particles in periodic potential
3. Bloch's theorem
4. Nearly free electron in three dimensions
5. Band structures of solids, tight binding model
6. Hartree-fock approximation, case of helium atom
7. Exchange and correlation in electron gas, screening
8. Methods of calculation band structures
9. Wannier functions
10. Pseudopotentials
11. Transport phenomena, boltzmann equation and electrical conduction
12. Solids in external magnetic field, pauli-paramagnetism of conduction electrons
13. Landau-diamagnetism of conduction electrons
14. De haas-van alphen effect
15. Quantum hall effect
16. Optical properties, kramer-kronig relation, excitons, mott-wannier excitons
17. Introduction and types of superconductivity
18. Flux quantization, london equations
19. Bardeen-cooper-schrieffer theory
20. Ginzburg-landua theory
21. Josephson effect
22. High T_c superconductivity, applications

Recommended Texts

1. Marder, M. P. (2015). *Condensed matter physics* (2^{nd} ed.). New Jersey: Wiley.
2. Ashcroft, N. W. & Mermin, N. D. (2003). *Solid state physics* (1^{st} ed.). Hong Kong: CBS Publishing Asia.

Suggested Readings

1. Ibach, H. & Lüth, H. (2009). *Solid states physics* (4^{th} ed.). New York: Springer.
2. Simon, S. H. (2013). *The oxford solid state basics* (1^{st} ed.). Oxford: Oxford University Press.
3. Kittle, C. (2005). *Introduction to solid state physics* (8^{th} ed.). New Jersey: Wiley.

PHYS-7104 Magnetism in Low Dimension 3(3+0)

The main objective of this course is to give students some introductory, basic and advanced knowledge of nanomagnetism and its applications. Basic phenomenon includes: Importance & origin of nanoscopic behavior of magnetic nanomaterials, Interactions in magnetic materials and allignment of spins or magnetic ordering due to these interactions, Advanced phenomenon includes exchange and magnetostatic coupling in magnetic multilayer systems & their applications. Some advanced experimental techniques to study different magnetic properties e.g, Magnetometery techniques (Vibrating sample magnetometer, SQUID, Kerr magnetometer) and Microscopy techniques (Magnetic force microscopy, Kerr Microscopy, Photo-emission electron microscopy) are part of this course.

Contents

1. Basis of nanomagnetism: magnetic dipole moment, orbial and spin angular momentum, magnetization, magnetic susceptibility
2. Types of magnetic materials: ferromagnetic, anti-ferromagnetic, feri-magnetic, paramagnetic and diamagnetic materials
3. Importance & origin of nanomagnetic behavior
4. Different type of magnetic energies or interactions (exchange, dipolar, anisotropy energies) in magnetic nanomaterials, magnetostriction
5. Zero, one & two dimensional nano magnetic materials: their size dependent properties (coercive field, curi temperature, magnetic dipole moment etc.) And applications
6. Exchange bias: mechanism, theoretical models and applications
7. Magnetic interlayer coupling: types of magnetic interlayer coupling, mechanism, theoretical models and applications
8. Magneto- optical effects: faraday and kerr effects
9. Magnetometry techniques: vibrating sample magnetometer, superconducting quantum interference device, kerr magnetometer
10. Magnetic microscopy techniques: magnetic force microscopy
11. Kerr microscopy, photo-emission
12. Electron microscopy
13. Applications of nanomagnetic materials: data storage devices

Recommended Texts

1. Blundell, S. (2001). *Magnetism in condensed matter*. Oxford: Oxford University Press.
2. Skomski, R. (2012). *Simple models of magnetism*. Oxford: Oxford University Press.

Suggested Readings

1. Hubert, A. & Schfer, R. (2008). *Magnetic domains: the analysis of magnetic microstructures*. Berlin: Springer Science & Business Media.
2. Guimaraes, A. P. (2017). *Principles of nanomagnetism*. New York: Springer.
3. Coey, J. M. D. (2010). *Magnetism and magnetic materials*. Cambridge: Cambridge University Press.

PHYS-7105 **Material Science** **3(3+0)**

The course Material Science is intended for students enrolling for M. Phil degree in Physics.New developments such as nanoscience and nanotechnology continue to propel materials science and engineering to the forefront of the studies around the world. Materials Science is an interdisciplinary subject, spanning the physics, chemistry of matter, engineering applications and industrial manufacturing processes. Materials scientists study the relationships between the structure and properties of a material and how it is made. Materials science and engineering is concerned with the generation and application of knowledge relating the composition, structure, and processing of materials to their properties and uses. This course is designed to provide students with a basic understanding of the various materials used in scientific and engineering applications. The purpose of this course is to provide key scientific and technical knowledge and data to students.On successful completion of this course students will be able to demonstrate the basic aspects of some advanced materials and their applications.

Contents

1. Self-consistent field approach
2. Random phase approximation and its application with many body problem
3. Two dimensional electron gas including magnetic field effects, electric field effects
4. Quantum wells
5. Multi-quantum wells structures
6. Super lattices
7. Band structure engineering of semiconductor super lattices
8. Molecular beam epitaxy
9. Role of mbe in forming low dimensional structures
10. Quantum hall effect
11. Conductivity tensor or resistivity tensor using kubo formula and maxwell boltzmann approximation
12. Linear and nonlinear effects
13. Application with graphene

Recommended Texts

1. William D., Callister, Jr. & David G. R. (2010). *Materials science and engineering an introduction* (8th ed.). New York: Wiley.
2. Robert A. E. (2012). *Quantum chemistry of solids.* Heidelberg: Springer.

Suggested Readings

1. Kittle, C. (2005). *Introduction to solid state physics* (8th ed.). New York: Wiley.
2. Lalauze, R. (2013). *Physico-chemistry of solid-gas interfaces: Concepts and methodology for gas sensor development*. New York: Wiley.
3. Douglas, B. & Ho, S. (2007). *Structure and chemistry of crystalline solids*. New York: Springer Science & Business Media.
4. Ashby, M. F. & Jones, D. (2012). *Engineering materials: an introduction to properties, applications and design* (3rd ed.). Oxford: Elsevier.

PHYS-7106 **X-ray Crystallography** **3(3+0)**

X-ray crystallography (XRC) is the experimental science which determines the atomic and molecular structure of a crystalline material. Crystalline structure causes a beam of incident X-rays to diffract into many specific directions usually labelled by Miller indices in the unit cell. By measuring the angles and intensities of these diffracted beams, a crystallographer can produce a three-dimensional picture of the density of electrons within the crystal. From the calculation of electron density, the mean positions of the atoms in the crystal can be determined, as well as their chemical bonds, their crystallographic disorder, and various other information. It will develop working and experimental knowledge of single crystal x-ray diffraction at graduate level.

Contents

1. Crystal systems, bravais lattices, and miller indices
2. Structure vs lattices
3. Optical diffraction and the laue and bragg experiments
4. The ewald construction and powder diffraction techniques
5. Reciprocal lattices, diffraction, mathematical definition of reciprocal lattices
6. Geometrical relationships to direct (bravais)-lattices
7. Role of reciprocal lattice in diffraction-the condition for constructive interference
8. Structural factors
9. Integrated intensities
10. Phase problems
11. Point groups
12. Space groups and systematic absences
13. Patterson technique and direct methods
14. Systematic absences and symmetry
15. Structure refinement, least squares
16. Debye-waller factors
17. Data collection
18. Unit cell, symmetry, and Intensities
19. Data reduction and structure solutions
20. Finishing touches

Recommended Texts

1. Ladd, M. & Palmer, P. (2014). *Structure determination by x-ray crystallography: analysis by x-rays and neutrons* (5th ed.). Boston: Springer.
2. Rhodes, G. (2010). *Crystallography made crystal clear: a guide for users of macromolecular models* (3rd ed.). Massachusetts: Academic Press.

Suggested Readings

1. Sands, D. E. (2012). *Introduction to crystallography* (2nd ed.). New York: Dover Publications.
2. Cullity B.D. & Stock, S.R. (2001). *Elements of x-ray diffraction* (3rd ed.). New York: Pearson.
3. Woolfson, M. & Hai-Fu, F. (2005). *Physical and non-physical methods of solving crystal structures* (2nd ed.). Cambridge: Cambridge University Press.

PHYS-7107 Pulsed Laser Deposition for Thin Film Growth 3(3+0)

This course provides a comprehensive overview of the pulsed laser deposition technique. Pulsed laser deposition is an exciting new film deposition process that can be applied to virtually any material from pure elements to six-element compounds. With pulsed laser deposition, researchers around the world are making high quality, epitaxial thin films of a wide range of different materials and studying their chemical and physical properties or utilizing them in advanced device implementations. Materials deposited by pulsed laser deposition include high Tc superconductors, ferrites, ferroelectrics, optoelectronics, metals, insulators, and biomaterials. This course provides a background in pulsed laser deposition fundamentals including plasma plume characteristic and growth kinetics. A comparison with other film deposition techniques will also be discussed.

Contents

1. Introduction to lasers, q-switching and mode-locking
2. Generation of pico-second and femto-second pulses
3. Different types of laser systems
4. Thin film deposition techniques
5. Fundamentals of pulsed laser deposition
6. Advantages and drawback of pld
7. Applications of pld
8. Equipment for thin film deposition
9. Mechanisms of pulsed laser sputtering
10. Diagnostics and characteristics of laser produced plasma
11. Particulates generated by pulsed laser ablation
12. Angular distribution of ablated material
13. Film nucleation and film growth
14. Process characteristics and film properties in pulsed laser plasma deposition
15. Novel pulsed laser deposition approaches
16. Rare-earth doped fluoride thin films
17. Future trends in pulsed laser deposition

Recommended Texts

1. Eason, R. (2007). *Pulsed laser deposition of thin films*. New York: John Wiley & Sons.
2. Cremers, D. A. & Radziemski, L. J. (2013). *Handbook of laser-induced breakdown spectroscopy*. New York: John Wiley & Sons.

Suggested Readings

1. Steen, W. M. (2003). *Laser material processing*. London: Springer.
2. Seshan, K. (2001). *Handbook of thin film deposition processes and techniques*. New York: William Andrew Publishing.
3. Hooker, S. & Webb, C. (2010). *Laser physics*, London: Oxford University Press.
4. Davis, C. C. (2014). *Lasers and electro-optics: fundamental and engineering*. Cambridge: Cambridge University Press.

PHYS-7108 **Low Temperature plasmas** **3(3+0)**

This is an introductory course to experimental plasma physics, with emphasis on low-temperature plasmas for different applications. Our planet is made of matter in the solid, liquid and gaseous states. Plasmas are unusual and exotic here. In fact the whole range of uses for plasmas has been discovered in just the last three or four decades. To create plasma energy has to be applied pretty quickly, before it is lost to the surroundings. Most plasma treatments rely on a synergy of physical bombardment of the surface and chemically reactive species, such as radicals. In this course the applications and properties of human-made and naturally occurring plasmas will be discussed. The aim of this course is to prepare students for more advanced courses on plasma physics and provide learning platform for research in plasma physics.

Contents

1. Plasma, plasmas in nature, plasmas in technology
2. Introduction to low temperature plasmas, non-equilibrium non-thermal plasma, degree of ionization
3. Concept of a distribution function, forms of the distribution function, boltzmann equilibrium electron temperature, electron energy distribution function
4. Debye length, quasi-neutrality, plasma parameter, plasma frequency, collisions, mean free path
5. Creating a low temperature plasma, low pressure plasmas, high pressure plasmas
6. Fluid approach, fluid equations, particle transport and loss, diffusion, mobility
7. Electrical breakdown, townsend's theory, paschen's law, minimum breakdown voltage
8. Self sustaining glow discharge, discharge structure
9. Dc discharges, sheath formation in a dc discharge, sheath potential at a floating wall, dc magnetron discharges, pulsed dc discharges
10. Plasma sources, why ac / rf?, capacitively coupled plasmas, circuit models
11. RF sheaths, ion energy distribution functions, plasma sustaining mechanisms, dual frequency capacitively coupled plasmas
12. Plasma sources, inductively coupled plasmas, inductive power coupling
13. Sparking, arc sources, linear arcs, plasma torches and jets, corona discharges
14. The dielectric barrier discharge, filamentary discharges, uniform discharges
15. Electrical breakdown at atmospheric pressure, atmospheric pressure plasma jets, micro plasmas
16. Diagnostics, probes, applications of low temperature plasmas

Recommended Texts

1. Chambert, P. & Braithwaite, N. (2011). *Physics of radio-frequency plasmas.* Cambridge: Cambridge University Press.
2. Lieberman, M. A. & Lichtenberg, A. J. (2005). *Principles of plasma discharges and materials processing* (2^{nd} ed.). New Jersey: Wiley.

Suggested Readings

1. Chen, F. F. & Chang, J. P. (2003). L*ecture notes on principles of plasma processing.* New York: Springer.
2. Roth, J. R. (2001). *Industrial plasma engineering* (1^{st} ed.). New York: Routledge.
3. Grill, A. (1993). *Cold plasma in materials fabrication.* New York: IEEE press.

PHYS 9109 **Chaos, Stability and Control** **3(3+0)**

Chaos theory, basically a branch of mathematical sciences having focus on the behavior of dynamical *systems* that are highly sensitive to initial conditions. It is an interdisciplinary theory having emphasis on that within the apparent randomness of complex chaotic systems, there are self-similarity, fractals, underlying patterns, self-organization, and reliance on programming at the initial point known as sensitive dependence on initial conditions. This course aims to develop mathematical techniques and to use theoretical frame work based on chaotic analysis while solving dynamical systems. After learning these techniques, students will be able to solve and control the dynamics of integrable and nearly integrable systems both in classical as well as quantum regimes.

Contents

1. Overview and basic concept:sensitive dependence on initial conditions
2. Examples of chaotic behavior, attractors
3. Area preserving maps: piecewise linear one-dimensional maps, the logistic map
4. Fractal dimensions: box counting dimension
5. Generalized baker's map
6. Canonical perturbation theory: power series, asymptotic series and small denominators, effect of resonances
7. Classical perturbation theory, adiabatic invariance
8. Secular perturbation theory
9. Dynamical properties of chaotic systems: the horseshoe map and symbolic dynamics, linear stability of steady states and periodic orbits, lyapunov exponents, entropies, controlling chaos
10. Chaos in hamiltonian systems: hamiltonian systems, chaos and kam tori in systems describable by two dimensional hamiltonian maps
11. Introduction to quantum chaos: waves functions in classically chaotic systems, eigen states of an integrable system, wave-packet dynamics, energy level spectra of chaotic (bounded, time independent systems), temporally periodic systems, wigner's distribution function in phase space, level dynamics
12. Quantum localization, chaos near resonances (basic concepts)

Recommended Texts

1. Alligoogd, K. T., Sauer, T. D. & Yorke, J. A. (1996). C*haos: an introduction to dynamical systems*. New York: Springer.
2. Lichtenberg, A. J. & Liberman, M. A. (1992). *Regular and chaotic dynamics* (2nd ed.). New York: Springer-Verlag.

Suggested Readings

1. Gutzwiller, M. C. (1990). *Chaos in classical and quantum mechanics*. New York: Springer-Verlag.
2. Haake, F. (2001). *Quantum signatures of chaos*. New York: Springer.
3. Baker, G. L. & Gollup, J. P. (1996). *Chaotic dynamics: an introduction* (2nd ed.). Cambridge: CambridgeUniversity Press.
4. Zaslavsky, G. M. (2007). *The physics of chaos in hamiltonian systems* (2nd ed.). London:Imperial College Press.

PHYS-7110 Introduction to Density Functional Theory 3(3+0)

Density-functional theory (DFT) is a computational quantum mechanical modelling method used in physics, chemistry, and material science to investigate the electronic or nuclear (principally the ground state) of many body systems, in particular atoms, molecules, and the condensed phases. DFT derives from the fundamental laws of quantum mechanics and describes the behavior of electrons- the glue that holds all matter together. Understanding the behavior of electrons therefore means understanding matter. DFT is a theoretical concept that has been turned into a computational tool with enormous success in physics, chemistry and materials science. DFT provides a parameter-free description of materials on the atomic scale and can be used to predict materials properties. This course assumes that you are familiar with the basics of DFT. It will go into more detail on the theoretical foundations of DFT, in particular the exchange-correlation functional, cover pros and cons of DFT, delve into the numerical realization of DFT and teach the practical aspects of performing DFT calculations in hands-on tutorial sessions.

Contents

1. Many body problem
2. Hartree-fock equations
3. Thomas fermi model
4. Density functional
5. Kohn-sham theorems
6. Kohn-sham equations
7. Exchange and correlation
8. Local density approximation
9. Generalized gradient approximation
10. Self-interaction correction
11. Hybrid functional
12. Linearized augmented plane wave method (lapw)
13. Full-potential lapw methods
14. Applications with wien 2k code

Recommended Texts

1. Engel, E. & Dreizler, R. M. (2011). *Density functional theory: an advanced course* (1st ed.). New York: Springer-Verlag.
2. Koch, W. & Holthausen, M. C. (2015). *A chemist guide to density functional theory* (2nd ed.). New York: Wiley.

Suggested Readings

1. Kohanoff, J. & Gidopoulos, N. I. (2003). *Density functional theory: basics, new trends and applications*. New York: Wiley.
2. Sholl, D. (2009). *Density functional theory: a practical introduction* (1st ed.). New York: Wiley.
3. Burke, K. & Wagner, L. (2007). *Abc of dft* (1st ed.). Irvine: CA-USA.
4. Parr, R. G. (2014). *Density functional theory of atoms and molecules* (6th ed.). Oxford: Oxford University Press.

PHYS-7111 Growth and Characterization of Solids 3(3+0)

The course of Growth and Characterization of Solids is intended for students enrolled for M. Phildegree in Physics.Materials are probably more deep-seated in our culture than most of us realize.Strictly speaking, materials science involves investigating the relationships that exist between the structures and properties of materials.One of the fascinating aspects of this course involves the investigation of a material's structure.The structure of materials has a profound influence on many properties of materials and their applications, even if the overall composition does not change. This courseintroduces an innovative pathway to understand the origin of materials, Crystal structure and imperfections, Growth processes of materials, recoveries in crystal structure of deformed materials and different types of materials with their functionality.

Contents

1. Imperfections in crystals
2. Impurities. vacancies. grain boundaries. dislocations. stacking faults
3. Frenkel and schottky disorder. color centers
4. Polymers and ceramics
5. Elastic and plastic deformation
6. Annealing effect of imperfection on the mechanical properties of materials
7. Modulation spectroscopy for optical properties in solids
8. Crystal optics. stress induced optical anomalies
9. Kinetic ordering and disordering. ferroelectric crystals
10. Chemical anisotropy. ordering of solid solution
11. Crystal growth
12. Quantum wells, multiquantum wells structures and super lattices
13. Doping super lattices, band structure engineering of semiconductor super lattices
14. Quantum well lasers
15. Use of quantum wells in enhancement of the efficiency of solar cells
16. MBE, its role in forming low dimensional structures
17. Classical hall effect
18. Quantum hall effect

Recommended Texts

1. Donald, R. A., Pradeep P. F. & Wendelin, J. W. (2010). *The science and engineering of materials* (6th ed.). New York: Cengage Learning.
2. Kittle,C. (2005). *Introduction to solid state physics*(8th ed.). New York. John Wiley & Sons.

Suggested Readings

1. Grasso, G. & Parravicini, G. (2014). *Solid state physics* (2nd ed.). Oxford: Academic Press.
2. William, D., Callister, Jr. & David G. R. (2010). *Materials science and engineering an introduction* (8th ed.). New York: John Wiley & Sons.
3. Douglas, B. & Ho, S. (2007). *Structure and chemistry of crystalline solids*. New York: Springer Science & Business Media.

PHYS-7112 **Atomic and molecular spectroscopy** **3(3+0)**

Atomic physics is a field of physics that involves investigation of the structures of atoms, their energy states, and their interactions with other particles and electromagnetic radiation. In this field of physics, atoms are studied as isolated systems made up of nuclei and electrons. Its primary concern is related to the arrangement of electrons around the nucleus and the processes by which these arrangements change. The aim of the course is to describe the atomic spectra of one and two valance electron atoms, on the basis of classical and quantum mechanical treatment. To write the energies and wave functions of different energy states of the various elements. Explain the change in behavior of atoms in external magnetic field. Using different coupling schemes, write the configuration and term values of energy states. Study of line profile and different line broadening mechanisms. To understand the concept of molecular orbitals, molecular energy levels and molecular structure.

Contents

1. Energy of the atomic states: classical model
2. Quantum mechanical treatment of hydrogen atoms
3. Radial wave functions, expectation values and most probable of finding the electron
4. Relativistic correction and spin orbit interaction
5. Fine structure and hyperfine structure
6. Interaction with external magnetic field: zeeman effect
7. Paschen back effect and lamb shift
8. Spectra of two electron atoms and concept of quantum defect
9. Electronic configuration
10. Angular momentum coupling schemes
11. Ls, lk, jk, jj coupling scheme
12. Hund's rules and selection rules for electric dipole transitions
13. Relative intensities
14. Einstein coefficient and life time
15. Line profile of spectral lines and line broadening mechanisms
16. Diatomic and polyatomic molecules
17. Molecular orbitals, molecular structure and molecular energy levels
18. Quantum mechanical treatment for a rigid rotor and non-rigid rotor
19. Spectra of di-atomic molecule

Recommended Texts

1. Demtroder, W. (2006). *Atoms, molecules and photons.* Berlin: Springer-Verlag.
2. Bernath, P.F. (2005). *Spectra of atoms and molecules.* (2nd ed.). Oxford : Oxford University Press.

Suggested Readings

1. Foot, C. J. (2005). *Atomic physics.* Oxford : Oxford University Press.
2. Brandsen, B. H., Joachian, C. J. & Plivier, T. J. (2003). *Physics of atoms and molecules*. London: Person Education.
3. Svangerg, S. (2004). *Atomic and molecular Spectroscopy.* Berlin: Springer.

PHYS-7113 Ion Physics (Methods and Instruments) 3(3+0)

The course aims to help M.Phil and Ph.D students learn experimental methods and develop experimental and scientific communication abilities in major areas of modern gas phase ion physics. Students develop skills including observing and measuring physical phenomena, analyzing and interpreting data clearly identifying and including possible sources of errors, and also reaching conclusions and publishing experimental results. Students also learn scientific presentation skills and how to read published results and references with appropriate judgment. A student taking this course will learn from the very initial processes of ion formation to their extraction and acceleration as ion beams, focusing ions and guiding them onto surfaces/detectors, pulsing ion beams in real time experiments as well in simulations.

Contents

1. Ionization methods: electrospray ionization
2. Chemical ionization, electron impact ionization, fast atom/ion bombardment ionization, field desorption and field ionization
3. Thermospray Ionization, maldi
4. Instrumentation: mass spectrometers (mass analyzers, magnetic sector, quadropole, tof, icrs)
5. Tandem mass spectrometry
6. Photoelectron spectroscopy, photoionization ms
7. Electron attachment spectroscopy
8. Electron transmission spectroscopy
9. Electron monochromators (energy analyzers)
10. Retarding field analyzers
11. Parallel plate analyzers
12. Cylindrical mirror analyzers
13. Wien filter
14. Trochoidal electron filter
15. Detectors: faraday cup collectors, electron multipliers, channeltrons, multichannel plates, photon detectors
16. Ion beam simulations (simion 8.1)

Recommended Texts

1. Schmidt, B. & Wetzig, K. (2013). *Ion beams in materials processing and analysis.* New York: Springer.
2. Ashcroft, A. E. (1997). *Ionization methods in organic mass spectrometry*. London: The Royal Society of Chemistry.

Suggested Readings

1. Illenberger, E. & Momigny, J. (1992). *Gaseous molecular ions.* New York: Springer.
2. Dahl, D. A. (2008). *Simion 3D user manual.* Idaho: Idaho National Engineering and Environmental Laboratory.

PhD
PHYSICS

PHYS-8101 **Quantum Field Theory** **3(3+0)**

Quantum field theory (QFT), body of physical principles combining the elements of quantum mechanics (QM) with those of relativity to explain the behavior of subatomic particles and their interactions via a variety of force fields. It is the mathematical and conceptual framework for contemporary elementary particle physics. In a rather informal sense QFT is the extension of QM, dealing with particles, over to fields, i.e. systems with an infinite number of degrees of freedom. In the last few years QFT has become a more widely discussed topic in philosophy of science, with questions ranging from methodology and semantics to ontology. QFT taken seriously in its metaphysical implications seems to give a picture of the world which is at variance with central classical conceptions of particles and fields, and even with some features of QM. QFT is used in particle physics to construct physical models of subatomic particles and in condensed matter physics to construct models of quasi-particles.

Contents

1. Classical field theory, lagrangian mechanics, variational principle and vibrating stings
2. Lorentz transformations and lorentz group, representations of lorentz group
3. Classical scalar fields and klein-gordon equation
4. Complex scalar fields and energy-momentum tensor
5. Electromagnetic field, maxwell’s equations and spinor field
6. Dirac equation, symmetries, and conservation laws
7. Noether’s theorem, translation invariance
8. Quantization of fields and canonical quantization of fields, quantization of scalar fields
9. Particle interpretation of quantum field theory
10. Normal ordering, non-hermitian fields
11. Interacting quantum fields and interacting fields
12. Perturbation theory and time ordering
13. S-matrix, cross-section, and decay rate of an unstable particle
14. Higher order perturbation theory and wick’s theorem
15. Second order perturbation theory
16. Feynman rules and diagrams, renormalization and mass renormalization
17. Coupling constant renormalization, field renormalization

Recommended Texts

1. Srednicki, M. A. (2007). *Quantum field theory* (1st ed.). Cambridge: Cambridge University Press.
2. Ryder, L. H. (1996). *Quantum field theory* (2nd ed.). Cambridge: Cambridge University Press.

Suggested Readings

1. Kaku, M. (1993). *Quantum field theory* (1st ed.). Oxford: Oxford University Press.
2. Bjorken, J. D. & Drell, S. D. (1965). *Relativistic quantum fields* (1st ed.). Cambridge: McGraw-Hill College.
3. Weinberg, S. (2005). *The quantum theory of fields* (1st ed.). Cambridge: Cambridge University Press.

PHYS-8102 **Plasma-Wall Interactions in Fusion Reactors** **3(3+0)**

To meet the future energy need of future, fusion is considered the most feasible and inexpensive source. In this course, students of M.Phil or Ph.D learn the deep insight of the fusion plasma wall interactions particularly the main challenges of next step fusion reactors, in particular after the introduction of mixed-materials as inner wall candidates. Physical concepts will be discussed in the context of important technological applications of energy. The physical concepts include Fission energy, Fusion energy, confinement of plasma and interactions of plasma constituents with inner walls of reactors. The technological applications include Field coils, erosion of wall-materials and ignition of fusion plasma.

Contents

1. Light nuclei and theory of fusion reactions
2. Next step fusion reactors: iter, jet, asdex-upgrade
3. Geometry of reactor: stellarators and toroidal configurations(tokamaks)
4. Wall materials and their respective physical and chemical properties regarding fusion plasma
5. Carbon, tungsten, beryllium etc. igniting the plasma
6. Lawson's criterion
7. Plasma confinement: inertial confinement, magnetic confinement
8. Energy requirements and gain
9. Charged particle motion: lagrange-hamilton orbit dynamics
10. Plasma kinetic theory: phase space, dynamics and kinetics, vlasov equation, fokker-plank
11. Plasm-edge parameters
12. Most prominent plasma-material interaction issues in next step fusion devices
13. Review of physical processes. sputtering, erosion, redeposition, erosion during off-normal plasma events
14. Hydrogen recycling and retention
15. Existing experimental database
16. Applications of models and predictions for next step tokamaks
17. Future research and development priorities
18. Ion-surface collisions (physical sputtering, surface induced chemical reactions, surface induced dissociation
19. Ion beam simulations (simion 8.1)

Recommended Texts

1. Kikuchi, M. (2010). *Frontiers in fusion research (physics and fusion).* New York: Springer.
2. Pfalzner, S. (2006). *An introduction to inertial confinement fusion*. Boca Raton: Taylor and Francis.

Suggested Readings

1. McCracken, G. & Stott, P. (2005). *Fusion, the energy of the universe.* Massachusetts: Elsevier.
2. Illenberger, E. & Momigny, J. (1992). *Gaseous molecular ions*. New York: Springer.
3. Dahl, D. A. (2008). *Simion 3D user manual.* Idaho: Idaho National Engineering and Environmental Laboratory.

PHYS-8103 M agnetization reversal and magnetization dynamics 3(3+0)

Nanoscopic particles may be constituent of magnetic recording media, Magnetc resonance imaging (MRI) contrast, drug carriers etc. Like other magnetic properties e.g, curi temperature, magnetic susceptibility, magnetization reversal also depends on size of nanostructures. To store data in conventional digital magnetic data storage devices, we apply magnetic field or current to reverse or switch bit. For certain critical nanoparticle size the reversal field can be zero and data bit will reverse spontaneously at room temperature resulting in destabilizing a bit which is not good for devices. Therefore it is necessary to understand magnetization reversal mechanisms in nanostructures not only to understand fundamental physics but also to better tune magnetic properties for devices and that's the main objective of this course.

Contents

1. Introduction
2. Three basic reversal mechanisms: coherent rotation of magnetization, nucleation & domain wall movement, domain formation
3. The stoner-wohlfarth model
4. Dynamic coercivity and temperature effects
5. Magnetization reversal in nanostructures (nanoparticles, nanowires and thin films) and their applications
6. Field induced magnetization reversal
7. Current induced magnetization reversal
8. Precessional dynamics of magnetization
9. Landu-lifshitz gilbert equation
10. Ferromagnetic resonance
11. Precessional switching of macrospins driven by fields
12. Precessional switching driven by spin transfer torques
13. Precessional dynamics of domain walls and vortices by field and current
14. Magnetic hetrostructures: From specific properties to applications
15. Coupling effects
16. Magnetotransport
17. Integration for applications

Recommended Texts

1. Guimaraes, A. P. (2017). *Principles of nanomagnetism*. New York: Springer.
2. Blundell, S. (2001). *Magnetism in condensed matter*. Oxford: Oxford University Press..

Suggested Readings

1. Zhu, Y. (2005). *Modern techniques for characterizing magnetic materials*. Berlin: Springer Science & Business Media.
2. Bruck, E. (2019). *Handbook of magnetic materials.* Amsterdam: North Holland
3. Coey, J. M. D. (2010). *Magnetism and magnetic materials*. Cambridge: Cambridge University Press.

PHYS-8104 Classical and Quantum Statistical Physics 3(3+0)

Statistical mechanics is concerned with the properties of matter on bulk scale and this study is carried out on the basis of the dynamical behavior of microscopic constituents of the matter. Devised with mathematical statistics and Hamiltonian mechanics, the formalism of statistical mechanics has proved to be of immense value to the physics. Quantum mechanically the dynamics of a physical system is represented by a set of quantum states and it mainly relies in determining the multiplicity of these states, hence constitutes the basis of quantum statistical mechanics. The aim of this course is to learn Classical and Quantum Statistical techniques in detail (as this course is compulsory at undergraduate level) and using them to explore theoretically the dynamical properties of matter for different physical systems.

Contents

1. Classical statistical physics:probability theory
2. Statistical ensembles and the statistical definition of entropy and free energy, interaction between macroscopic system
3. Macroscopic thermodynamics and its applications
4. Maxwell relations
5. Thermodynamics potentials
6. The partition function for simple systems, phase transitions
7. uantum statistics of ideal gases
8. Transport theory using kinetic, relaxation and boltzmann-equation methods, irreversible process and fluctuations
9. The basic concept of quantum statistics:the basic principle statistical mechanics of quantum systems
10. The adiabatic process:thermodynamic functions, statistical operators of molecular complexes, the application to system of monoatomic spin-less molecules
11. The method of second quantization:the second quantizationrepresentation of wave functions second quantization representation for dynamical variables; relation to themethod of statistical process
12. The case of bose statistics
13. The case of Fermi statistics
14. The theory of thebose-einstein gas and its application to an investigation of the phenomenon of superfluidity

Recommended Texts

1. Reif, F. (2013). *Fundamentals of statistical and thermal physics*. New York: McGraw-Hill.
2. Bogolubov, N. N. & Bogolubov Jr. N. (2010). *I ntroduction to quantum statisticalmechanics* (2nd ed.). New Jersey: world Scientific.

Suggested Readings

1. Huang, K. (2001). *Introduction to statistical physics* (2nd ed.). London: Taylor & Francis.
2. Bogoliubov, N. N. & Gordon, B. (1985). *Lectures on quantum statistics*. Boston: Science Publishers.

PHYS-8105 **Advance Material Science** **3(3+0)**

The course Advance Material Science is intended for students enrolled for Ph.D. degree in Physics. Modern society is severely dependent on advanced materials: lightweight composites for faster vehicles, optical fibers for telecommunications and silicon microchips for the information revolution. The progress of many technologies that make our existence so comfortable has been intimately associated with the accessibility of appropriate materials. An advancement in the understanding of a material properties is often the forerunner to the stepwise evolution of a technology. Today, materials engineering and science advances are more closely synchronized. Actually, the purpose of this course is to provide key scientific and technical knowledge on the behavior of functional materials and devices.Properties of materials depend on their internal structures. Relationship between properties and internal structures of materials and how these can be changed are also within the scope of this course.Graphene has the potential to revolutionize the materials world, and participants of this course will also learn about somecertain applications ofgraphene.This course will enable students to understand the applications and selection of certain materials based on the consideration of properties, cost, ease of manufacture, environmental issues and their in service performance.

Contents

1. Non-equilibrium green’s function including many body transport dynamics
2. Non-equilibrium transport in mesoscopic systems
3. Real time green’s function
4. Transport in inversion layer
5. Desnity matrix
6. Wigner distribution
7. Molecular beam epitaxy, its role in forming low dimensional structures
8. Quantum hall effect
9. Conductivity tensor or resistivity tensor using kubo formula and maxwell boltzmann approximation
10. Linear and nonlinear effects
11. Application with graphene
12. Green’s function transport dynamics in high electric field

Recommended Texts

1. William, D., Callister, Jr. & David, G. R. (2010). *Materials science and engineering an Introduction* (8thed.). New York: John Wiley & Sons.
2. Douglas, B. & Ho, S. (2007). *Structure and chemistry of crystalline solids*. New York: Springer.

Suggested Readings

1. Ashby, M. F. & Jones, D. (2012). *Engineering materials: an introduction to properties, applications and design* (3rd ed.). Oxford: Elsevier.
2. Grasso, G. & Parravicini, Gp. (2014). *Solid state physics* (2nd ed.). Oxford: Academic Press.
3. Wilde, G. (2009). *Nanostructured materials.*Oxford: Elsevier.
4. Robert A. E. (2012). *Quantum chemistry of solids.* Heidelberg: Springer.

PHYS-8106 **Nonlinear Physics** **3(3+0)**

Almost all real systems are nonlinear, as in these systems, superposition principle fails to work i.e.,the system does not respond proportional to the input that it receives. In other words, the effects are not simply linear function of their causes, and is associated with coded but well-known words like chaos, fractals, Solitons, cellular automata, and complex systems. Nonlinear phenomena are important in many fields, including dynamical systems, fluid dynamics, material science, statistical physics, and particle physics. This course will enable students to apply the concepts of nonlinear physics into their areas of research for better understanding at the micro and macroscopic levels. This course provides the students the up-to-date treatment of classical mechanical systems and serves as basics and pre-requisite of Quantum Mechanics so that students face least difficulty in entering from classical Physics to Quantum mechanics.

Contents

1. Non-linearity and non linear effects, superposition principle, harmonic and anharmonic oscillators, pendulum, phase portrait, harmonic balance method, frequency shifts, background modification
2. Driven damped duffing oscillator, non linear resonance, deterministic chaos, logistic map, fixed points and stability of 1-d maps, transients and attractors, period doubling, butterfly effect(sic), bifurcation diagram, universality, feigenbaum numbers, self-similarity, lyapunov exponent, maps and flows, phase space , rayleigh bernard convection and lorenz model, dynamical flows, fixed points and stability, dissipative and conservative systems, autonomous and non-autonomous systems, strange attractor, fractal character, fractals, hausdorff dimension, bifurcation diagram, periodic and chaotic behavior
3. Wave equation and dispersion relation, dispersive waves, types of linear waves, superposition principle, carrier wave and wave modulation, amplitude dependent phase velocity and non-linear effects, solitary waves, dispersion and non-linearity, experimental observation, kdv equation, solitary wave solution, fpu recurrence, soliton collisional property, evolution of arbitrary pulse soliton amplitude, speed and width, reductive perturbation method
4. Envelope and carrier wave nonlinear schrodinger equation, solitary wave solution, communications, optical fibers and optical solitons, attenuation, dispersion and non-linearity parameters.

Recommended Texts

1. Yashida, Z. (2010). *Nonlinear science: the challenge of complex systems*. London: Springer.
2. Schuster, R. (2005). *Deterministic chaos*. Berlin: Wiley.

Suggested Readings

1. Hilborn, R. (1994). *Chaos and non lineardynamics: an introduction for scientists and engineers*. Oxford: Oxford University Press.
2. Thompson, J. M. T. & Stewart, H. B.(2002). *Nonlinear dynamics and chaos* (2nd ed.). West Sussex: John Wiley & Sons.
3. Acton, J. R. & Squire, P. T. (1985). *Solvingequations with physical understanding* (1st ed.). Florida: CRC press.

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PHYS 8107 **Laser Spectroscopy: Experimental Techniques** **3(3+0)**

This course provides students a comprehensive overview of the basic methods and techniques of various instruments developed for laser spectroscopy. Laser spectroscopy is a versatile diagnostic tool for analytical applications and recent advances in semiconductor laser technology combined with selective and sensitive spectroscopic detection techniques have led to the development of new diagnostic tools for trace gas and isotope analysis. A student taking this course will learn different spectroscopic techniques and applications of laser spectroscopy. The aim of this course is to describe, in words, the ways in which various spectroscopic techniques come into play in particular situations and provide learning platform for research in laser spectroscopy.

Contents

1. Spectroscopic Instrumentation, laser and spectroscopic light sources
2. Nonlinear optical mixing techniques
3. Advantages of lasers in spectroscopy
4. High sensitivity methods of absorption spectroscopy
5. Ionization spectroscopy
6. Optogalvanic spectroscopy
7. Laser magnetic resonances
8. Stark spectroscopy
9. Laser induced fluorescence
10. Polarization spectroscopy
11. Multiphoton spectroscopy
12. Time-resolved laser spectroscopy, measurement of ultrashort pulses
13. Lifetime measurements with lasers, spectroscopy in the pico-to-attosecond range
14. High resolution laser spectroscopy
15. Spectroscopic techniques
16. Photoionization cross section and oscillator strength, different techniques to measure the photoionization cross section and oscillator strength
17. New developments in laser spectroscopy
18. Spectroscopy of single ions
19. Atomic interferometery
20. Applications of laser spectroscopy

Recommended Texts

1. Demtroder, D. (2008). *Laser spectroscopy: basic principles* (4^{th} ed.). Berlin: Springer.
2. Demtroder, D. (2008). *Laser spectroscopy: experimental techniques* (4^{th} ed.). Berlin: Springer.

Suggested Readings

1. Corney, A. (2006). *Atomic and laser spectroscopy.* Oxford: Oxford University Press.
2. Abramczyk, H. (2005). *Introduction to laser spectroscopy.* New York: Elsevier.
3. Svangerg, S. (2004). *Atomic and molecular spectroscopy.* (4^{th} ed.). Bristel: Springer.

PHYS-8108 **Electromagnetic Theory** **3(3+0)**

This course is the continuation and extension of "Electrodynamics-I and Electrodynamics-II. The basic concept behind the course is, a charge creates an Electric field when it is at rest and it creates both electric as well as magnetic field when charge is in motion. Our objective is to study generation and propagation of electromagnetic waves in different mediums. Derive Poynting's theorem from Maxwell's equations and interpret the terms in the theorem physically. Describe and make calculations of plane electromagnetic waves in homogeneous media, including reflection of such waves in plane boundaries between different homogeneous media.

Contents

1. Maxwell's equations
2. Gauge transformation
3. Poynting vector, conservation laws
4. Plane electromagnetic waves in a nonconducting and conducting medium
5. Polarization. propagation in a dispersive medium
6. Reflection and refraction
7. Total internal reflection
8. Radiation by moving charges
9. Lienard-wiechert potentials and fields
10. General angular and frequency distributions of radiation from accelerated charges
11. Thompson scattering
12. Cherenkov radiation
13. Fields and radiation of localized oscillating sources
14. Electric dipole fields and radiation
15. Magnetic dipole and electric quadrupole fields
16. Multipole fields
17. Multipole expansion of the electromagnetic fields
18. Angular distributions. sources of multipole radiation
19. Spherical wave expansion of a vector plane wave
20. Scattering of electromagnetic wave by a conducting sphere

Recommended Texts

1. Griffiths, D. J. (2017). *Introduction to electrodynamics* (4^{th} ed.). Cambridge: University Press.
2. Cheng, D. K. (2004). *Field and wave electromagnetics* (2^{nd} ed.). New York: Pearson Education.
3. Tougaw, D. (2018). *Applied electromagnetic field theory.* Valparaiso: Valparaiso University.

Suggested Readings

1. Thide, B. (2004). *Electromagnetic field theory.* Uppsala: Uppsala University Press.
2. Feynman, R. P., Robert, L. B. & Matthew, S. (2011). *The feynman lectures on physics.* Now York: Addison-Wesley.

PHYS-8109 Plasma Processing and Technology 3(3+0)

This is an advance course on experimental plasma physics, with emphasis on low-temperature plasmas for different applications. In fact the whole range of uses for plasmas has been discovered mainly in just the last three or four decades. To create plasma energy has to be applied pretty quickly, before it is lost to the surroundings. Most plasma treatments rely on a synergy of physical bombardment of the surface and chemically reactive species, such as radicals. In this course the applications and properties of human-made and naturally occurring plasmas will be discussed. The aim of this course is to describe, in words, the ways in which various concepts in low-temperature plasmas come into play in particular situations and provide learning platform for research in plasma physics.

Contents

1. Plasma applications, low pressure, high temperature plasmas
2. Thermal plasmas, non-thermal plasmas, specific applications
3. Lighting, lasers, plasma displays, plasma etching, plasma deposition
4. Polymer and textile processing
5. Ozone production, molecular plasmas
6. Collisions, cross sections, reaction rates, diffusion
7. An oxygen plasma
8. Plasma kinetics rate equations, power balance, the numerical method
9. Plasma surface interactions, solids and surfaces
10. Adsorption and desorption, surface reactions, surface energy, interaction of energetic heavy particles with surfaces
11. Secondary electron production, potential emission, radiative recombination, potential electron emission (auger emission), kinetic secondary electron emission
12. Sputtering, reflection, entrapment and implantation
13. Surface chemistry, adsorption, sticking coefficient
14. Desorption surface kinetics, reactions at a surface, reactions with the surface, reactions on a surface
15. Etching, etch rate, selectivity, anisotropy, etch processes, sputtering, chemical etching, ion energy driven etching, ion inhibitor etching, etching kinetics, surface kinetics
16. Fluorocarbon etching of SiO_2 and Si, selectivity. anisotropy, plasma and surface kinetics

Recommended Texts

1. Chambert, P. & Braithwaite, N. (2011). *Physics of radio-frequency plasmas.* Cambridge: Cambridge University Press.
2. Lieberman, M. A. & Lichtenberg, A. J. (2005). *Principles of plasma discharges and materials processing* (2nd ed.). New Jersey: Wiley.

Suggested Readings

1. Chen, F. F. & Chang, J. P. (2003). L*ecture notes on principles of plasma processing.* New York: Springer.
2. Roth, J. R. (2001). *Industrial plasma engineering* (1st ed.). Routledge: Taylor & Francis.