CHOICE BASED CREDITSYSTEM

B. SC. PHYSICS (Honours Course) Syllabus (Reduced Syllabus for the Session 2020-21)

Department of Physics
Bodoland University
BTAD, Kokrajhar-783370
Assam.

(Reduced Syllabus for the Session 2020-21 only)

Department of Physics
Bodoland University
Curriculum Structures for UG syllabus (B.Sc. Honours)
No. of papers =14+12=26, Total Credits= 140
Total Marks = 2400

SEM-I						
Paper Code	**Course**	**Credit**	**Credit Distribution (L+T+P)**	**End Sem Marks**	**Internal Marks**	**Total Marks**
PHY-101H	C-1: Mathematica Phyiscs-I	6	4+0+2	60(Theo)+20(Pract)	20	100
PHY-102H	C-2: Mechanics	6	4+0+2	60(Theo)+20(Pract)	20	100
PHY-101R	GE-1: Mechanics	6	4+0+2	60(Theo)+20(Pract)	20	100
COMM-104HR	AECC-1: English/Hind/MIL (Communication)	2	2+0+0	50	-	50
Total		**20**	**20**	**290**	**60**	**350**

SEM-II						
Paper Code	**Course**	**Credit**	**Credit Distribution (L+T+P)**	**End Sem Marks**	**Internal Marks**	**Total Marks**
PHY-201H	C-3: Electricity & Magnetism	6	4+0+2	60(Theo)+20(Pract)	20	100
PHY-202H	C-4: Waves and Optics	6	4+0+2	60(Theo)+20(Pract)	20	100
PHY-201R	GE-2: Electriciy, Magnetism and EMT	6	4+0+2	60(Theo)+20(Pract)	20	100
ENV-204HR	AECC-2: Environmental Science	2	2+0+0	50	-	50
Total		**20**	**20**	**290**	**60**	**350**

(Reduced Syllabus for the Session 2020-21 only)

SEM-III						
Paper Code	**Course**	**Credit**	**Credit Distribution (L+T+P)**	**End Sem Marks**	**Internal Marks**	**Total Marks**
PHY-301H	C-5: Mathmatical Physics - II	6	4+0+2	60(Theo)+20(Pract)	20	100
PHY-302H	C-6: Thermal Physics	6	4+0+2	60(Theo)+20(Pract)	20	100
PHY-303H	C-7: Digital System and applications	6	4+0+2	60(Theo)+20(Pract)	20	100
PHY304HR	SEC-1Physics workshopskill	2	2+0+0	50	-	50
PHY-301R	GE-3: Thermal Physics and statistical mechanics	6	4+0+2	60(Theo)+20(Pract)	20	100
Total		**26**	**26**	**370**	**80**	**450**

SEM-IV						
Paper Code	**Course**	**Credit**	**Credit Distribution (L+T+P)**	**End Sem Marks**	**Internal Marks**	**Total Marks**
PHY-401H	C-8: Mathmatical Physics - III	6	4+0+2	60(Theo)+20(Pract)	20	100
PHY-402H	C-9: Elements of modern physics	6	4+0+2	60(Theo)+20(Pract)	20	100
PHY-403H	C-10: Analog system & applications	6	4+0+2	60(Theo)+20(Pract)	20	100
PHY-404HR	SEC-2: Computational Physics Skill	2	2+0+0	50	-	50
PHY-401R	GE-4: Waves and Optics	6	4+0+2	60(Theo)+20(Pract)	20	100
Total		**26**	**26**	**370**	**80**	**450**

(Reduced Syllabus for the Session 2020-21 only)

SEM-V						
Paper Code	**Course**	**Credit**	**Credit Distribution (L+T+P)**	**End Sem Marks**	**Internal Marks**	**Total Marks**
PHY-501H	C-11: Quantum Mechanics & applications	6	4+0+2	60(Theo)+20(Pract)	20	100
PHY-502H	C-12: Solid State Physics	6	4+0+2	60(Theo)+20(Pract)	20	100
PHY-503H	DSE-1: Advanced Mathematical Physics-I	6	4+0+2	60(Theo)+20(Pract)	20	100
PHY-504H	DSE-2: Nuclear and Particle Physics	6	5+1+0	80	20	100
Total		**24**	**24**	**320**	**80**	**400**

SEM-VI						
Paper Code	**Course**	**Credit**	**Credit Distribution (L+T+P)**	**End Sem Marks**	**Internal Marks**	**Total Marks**
PHY-601H	C-13: Electromagnetic Theory	6	4+0+2	60(Theo)+20(Pract)	20	100
PHY-602H	C-14: Statistical Mechanics	6	4+0+2	60(Theo)+20(Pract)	20	100
PHY-603H	DSE-3: Classical Dynamics	6	5+1+0	80	20	100
PHY-604H / PHY-604D	DSE-4: Experimental Technices / Dissertation	6	4+0+2	60(Theo)+20(Pract) or 80 for dissertation	20	100
Total		**24**	**24**	**320**	**80**	**400**

(Reduced Syllabus for the Session 2020-21 only)

B. Sc. Physics (Honours course) syllabus under CBCS

Semester	CORE COURSE (14)	Ability Enhancement Compulsory Course (AECC) (2)	Skill Enhancement Course (SEC) (2)	Discipline Specific Elective (DSE) (4)	Generic Elective (GE) (4)
I	***C1: Mathematical Physics-I (4+2)***	(English/Hindi/MIL Communication)			GE-1
	C2: Mechanics (4+2)				
II	***C3: Electricity & Magnetism (4+2)***	Environmental Science			GE-2
	C4: Waves and Optics (4+2)				
III	***C5: Mathmatical Physics-II (4+2)***		SEC-1 **(Physics workshop skill)**		GE-3
	C6:Thermal physics (4+2)				
	C7: Digital systems and applications (4+2)				
IV	***C8: Mathmatical Physics-III (4+2)***		SEC-2 **(Computational physics skill)**		GE-4
	C9: Elements of modern physics (4+2)				
	C10: Analog systems & applications (4+2)				
V	***C11: Quantum Mechanics & applications (4+2)***			DSE-1: **Advanced Mathematical Physics-I (4+2)**	
	C12:Solid State Physics (4+2)			DSE-2: **Nuclear and Particle Physics (5+1)**	
VI	***C13: Electromagnetic Theory (4+2)***			DSE-3: **Classical Dynamics (5+1)**	
	C14: Statistical Mechanics (4+2)			DSE-4: **Experimental Techniques (4+2) or Dissertation (6)**	

Note: Physics student must opt at least two generic elective papers from mathematics to pursue M.Sc.in physics.

(Reduced Syllabus for the Session 2020-21 only)

List of Physics generic elective for other discipline:

GE-1: Mechanics (4) + Lab (2)

GE-2: Electricity, Magnetism and EMT (4) + Lab (2)

GE-3: Thermal Physics and Statistical Mechanics (4) + Lab (2)

GE-4: Waves and Optics (4) + Lab (2)

List of Discipline specific elective(DSE):

DSE-1: Advanced Mathematical Physics-I (4+2)

DSE-2: Nuclear and Particle Physics(5+1)

DSE-3: Classical Dynamics (5+1)

DSE-4: Experimental Techniques (4+2) ***or*** Dissertation (6)

List of Skill Enhancement Course (SEC):SEC -1: Physics Workshop Skill

(2) SEC–2: Computational Physics Skill

(2)

Semester I

PHYSICS-C 1: MATHEMATICAL PHYSICS-I
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Calculus:
Recapitulation: Limits, continuity, average and instantaneous quantities,differentiation.Approximation: Taylor and binomial series (statements only). **(2 Lectures)**

FirstOrderandSecondOrderDifferentialequations:FirstOrderDifferentialEquations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. **(13 Lectures)**

Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. **(6 Lectures)**

Vector Calculus:
Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively.
(5 Lectures)

Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalarfieldanditsgeometricalinterpretation.Divergenceandcurlofavectorfield.Del and Laplacian operators. **(8Lectures)**

Vector Integration: Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications(no rigorous proofs). **(14Lectures)**

Orthogonal Curvilinear Coordinates:
Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems. **(6 Lectures)**

Introduction to probability:
Independent random variables: Probability distribution functions;binomial,Gaussian, and Poisson, with examples. Mean and variance.

(4Lectures)

Dirac Delta function and its properties:
Definition of Dirac delta function. Properties of Dirac delta function. **(2Lectures)**

Reference Books:

- Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn.,Elsevier.
- Anintroductiontoordinarydifferentialequations,E.A.Coddington,2009,PHIlearning
- Differential Equations, George F. Simmons, 2007, McGrawHill.
- Mathematical Tools for Physics, James Nearing, 2010, DoverPublications.
- MathematicalmethodsforScientistsandEngineers,D.A.McQuarrie,2003,VivaBook
- AdvancedEngineeringMathematics,D.G.ZillandW.S.Wright,5Ed.,2012,Jones and BartlettLearning
- Mathematical Physics, Goswami, 1st edition, CengageLearning
- EngineeringMathematics,S.PalandS.C.Bhunia,2015,OxfordUniversityPress
- Advanced Engineering Mathematics, Erwin Kreyszig, 2008, WileyIndia.
- EssentialMathematicalMethods,K.F.Riley&M.P.Hobson,2011,CambridgeUniv.Press

PHYSICS - C 1 LAB:

60 Lectures

TheaimofthisLabisnotjusttoteachcomputerprogrammingandnumericalanalysis but to emphasize its role in solving problems inPhysics.

- *Highlights the use of computational methods to solve physicalproblems*
- *Thecoursewillconsistoflectures(boththeoryandpractical)intheLab*
- *Evaluationdonenotontheprogrammingbutonthebasisofformulatingtheproblem*
- *Aimatteachingstudentstoconstructthecomputationalproblemtobesolved*
- *StudentscanuseanyoneoperatingsystemLinuxorMicrosoftWindows*

Topics	Description with Applications
Introduction and Overview	Computer architecture and organization, memory and Input/output devices

Basics of scientific computing	Binaryanddecimalarithmetic,Floatingpointnumbers, algorithms,Sequence,SelectionandRepetition,single anddoubleprecisionarithmetic,underflow&overflow-emphasizetheimportanceofmakingequationsinterms of dimensionless variables, Iterativemethods
Errors and error Analysis	Truncationandroundofferrors,Absoluteandrelative errors, Floating pointcomputations.
Review of C & C++ Programming fundamentals	IntroductiontoProgramming,constants,variablesand datatypes,operatorsandExpressions,I/Ostatements, scanfandprintf,cinandcout,Manipulatorsfordata formatting, Control statements (decision making and loopingstatements)(*If-statement.If-elseStatement. NestedifStructure.Else-ifStatement.TernaryOperator. Goto Statement. Switch Statement. Unconditional and ConditionalLooping.WhileLoop.Do-WhileLoop.FOR Loop. Break and Continue Statements. Nested Loops*), Arrays(*1D&2D*)andstrings,userdefinedfunctions, Structures and Unions, Idea of classes and objects
Programs:	Sum&averageofalistofnumbers,largestofagiven list of numbers and its location in the list, sorting of numbersinascendingdescendingorder,Binarysearch
Random number generation	Area of circle, area of square, volume of sphere, value of pi **(π)**
SolutionofAlgebraicandTranscendental equationsbyBisection,NewtonRaphson and Secantmethods	Solution of linear and quadratic equation, solving $\alpha = \tan\alpha; I = I_0\left\lvert \frac{(\sin\alpha)^2}{\alpha} \right\rvert$ in optics
Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation	Evaluation of trigonometric functions e.g. *sin θ, cos θ, tan θ, etc.*
Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method	Given Position with equidistant time data to calculate velocityandaccelerationandviceversa.Findtheareaof B-H Hysteresisloop

Solution of Ordinary Differential Equations (ODE) FirstorderDifferentialequationEuler, modified Euler and Runge-Kutta(RK) second and fourth ordermethods	First order differential equation • Radioactivedecay • Current in RC, LC circuits with DCsource • Newton's law ofcooling • Classical equations ofmotion Attempt following problems using RK 4 order method: • Solve the coupled differentialequations $\frac{dx}{dt} = y + x - \frac{x^3}{3}; \frac{dy}{dx} = -x$ for four initial conditions x(0)=0,y(0)=-1,-2,-3,-4. Plotxvsyforeachofthefourinitialconditionson the same screen for $0 \le t \le 15$ The differential equation describing the motion of a pendulumis $\frac{d^2P}{dt^2} = -\sin(P)$.Thependulumisreleased from rest at an angular displacement α, i. e. $P(0) = \alpha$ and $P'(0) = 0$.Solvetheequationforα=0.1,0.5 and1.0andplotPasafunctionoftimeintherange$0 \le t \le 8\pi$. Also plot the analytic solution valid for small P ($\sin(P) = P$

Referred Books:

- IntroductiontoNumericalAnalysis,S.S.Sastry,5th Edn.,2012,PHILearningPvt.Ltd.
- Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw-HillPub.
- NumericalRecipesinC:TheArtofScientificComputing,W.H.Pressetal,3rd Edn. , 2007, Cambridge University Press.
- A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHILearning.
- Elementary Numerical Analysis, K.E. Atkinson, 3 rd Edn . , 2007 , Wiley IndiaEdition.
- NumericalMethodsforScientists&Engineers,R.W.Hamming,1973,CourierDoverPub.
- An Introduction to computational Physics, T.Pang, 2nd Edn. , 2006,Cambridge Univ.Press
- Computational Physics, Darren Walker, 1st Edn., 2015, Scientific International Pvt.Ltd.

PHYSICS-C *2*: MECHANICS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Fundamentals of Dynamics: Reference frames. Inertial frames; Review of Newton's LawsofMotion. Motion of a projectile in Uniform gravitational field Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse. **(6Lectures)**

Work and Energy: Work and Kinetic Energy Theorem. Conservative and non-conservativeforces.PotentialEnergy.Energydiagram.Stableandunstableequilibrium. Elasticpotentialenergy.Forceasgradientofpotentialenergy.Work&Potentialenergy. **(4 Lectures)**

Collisions: Elastic and inelastic collisions between particles. Centre of Mass. **(3Lectures)**

Rotational Dynamics: Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical bodies. **(12Lectures)**

Elasticity: Relation between Elastic constants.

(3Lectures)

FluidMotion: Kinematics of Moving Fluids:Poiseuille's Equation forFlowofaLiquid through a CapillaryTube. **(2Lectures)**

Gravitation and Central Force Motion: Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell. **(3Lectures)**

Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. Kepler's Laws. Satellite in circular orbit and applications.

(6Lectures)

Oscillations:SHM:SimpleHarmonicOscillations.DifferentialequationofSHMandits solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, **(7Lectures)**

Non-Inertial Systems: Non-inertial frames and fictitious forces. Uniformly rotating frame.LawsofPhysicsinrotatingcoordinatesystems.Centrifugalforce.Coriolisforce and its applications. **(4Lectures)**

Special Theory of Relativity: Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities. Variation of mass with velocity. Mass-energy Equivalence. (**10Lectures)**

Reference Books:

- Anintroductiontomechanics,D.Kleppner,R.J.Kolenkow,1973,McGraw-Hill.
- Mechanics,BerkeleyPhysics,vol.1,C.Kittel,W.Knight,et.al.2007,TataMcGraw-Hill.
- Physics, Resnick, Halliday and Walker 8/e. 2008,Wiley.
- AnalyticalMechanics,G.R.FowlesandG.L.Cassiday.2005,CengageLearning.
- FeynmanLectures,Vol.I,R.P.Feynman,R.B.Leighton,M.Sands,2008,PearsonEducation
- IntroductiontoSpecialRelativity,R.Resnick,2005,JohnWileyandSons.
- University Physics, Ronald Lane Reese, 2003, ThomsonBrooks/Cole.

Additional Books for Reference

- Mechanics, D.S. Mathur, S. Chand and Company Limited,2000
- UniversityPhysics.F.WSears,M.WZemansky,H.DYoung13/e,1986,AddisonWesley
- PhysicsforscientistsandEngineerswithModernPhys.,J.W.Jewett,R.A.Serway, 2010, CengageLearning
- Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGrawHill.

PHYSICS - C *2* LAB 60

Lectures

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travellingmicroscope.
2. To study the random error inobservations.
3. To determine the height of a building using aSextant.
4. To study the Motion of Spring and calculate (a) Spring constant, (b) **g** and (c) Modulus ofrigidity.
5. To determine the Moment of Inertia of aFlywheel.
6. Todetermine**g**andvelocityforafreelyfallingbodyusingDigitalTimingTechnique
7. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
8. TodeterminetheYoung'sModulusofaWirebyOpticalLeverMethod.
9. TodeterminetheModulusofRigidityofaWirebyMaxwell'sneedle.
10. To determine the elastic Constants of a wire by Searle'smethod.
11. To determine the value of g using BarPendulum.
12. To determine the value of g using Kater'sPendulum.

Reference Books

- Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia PublishingHouse
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann EducationalPublishers
- ATextBookofPracticalPhysics,I.Prakash&Ramakrishna,11thEdn,2011,KitabMahal
- Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt.Ltd.
- Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge UniversityPress.

GE - 1: MECHANICS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Vectors: Vector algebra. Scalar and vector products. **(4Lectures)**

Ordinary Differential Equations: 1st order homogeneous differential equations. 2nd order homogeneous differential equations with constantcoefficients. **(6Lectures)**

Laws of Motion: Frames of reference. Newton's Laws of motion. **(10Lectures)**

Momentum and Energy: Conservation of momentum. Work and energy. Conservation of energy. **(6Lectures)**

Rotational Motion: Angular velocity and angular momentum.Torque. **(5Lectures)**

Gravitation: Newton's Law of Gravitation. Motion of a particle in a central forcefield (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statement only).

(8Lectures)

Oscillations: Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. **(6Lectures)**

Elasticity: Hooke's law - Stress-strain diagram - Elastic moduli-Relation between elastic constants - Poisson's Ratio-Expression for Poisson's ratio in terms of elastic constants-Workdoneinstretchingandworkdoneintwistingawire-Twistingcouple on a cylinder. **(8Lectures)**

Special Theory of Relativity: Constancy of speed of light. Postulates of Special Theory of Relativity. Length contraction. Time dilation. **(7 Lectures)**.

- **ReferenceBooks:**

- University Physics. F.W. Sears, M.W. Zemansky and H.D. Young, 13/e, 1986. Addison-Wesley
- MechanicsBerkeleyPhysics,v.1:CharlesKittel,et.al.2007,TataMcGraw-Hill.
- Physics – Resnick, Halliday & Walker 9/e, 2010,Wiley
- Engineering Mechanics, Basudeb Bhattacharya, 2nd edn., 2015, Oxford UniversityPress
- University Physics, Ronald Lane Reese, 2003, ThomsonBrooks/Cole.

GE - 1 LAB: MECHANICS
60 Lectures

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travellingmicroscope.
2. To determine the Height of a Building using aSextant.
3. To determine the Moment of Inertia of aFlywheel.
4. TodeterminetheYoung'sModulusofaWirebyOpticalLeverMethod.
5. TodeterminetheModulusofRigidityofaWirebyMaxwell'sneedle.
6. TodeterminetheElasticConstantsofaWirebySearle'smethod.
7. To determine g by BarPendulum.
8. To determine g by Kater'sPendulum.
9. TostudytheMotionofaSpringandcalculate(a)SpringConstant,(b)g.

Reference Books:

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop,1971, Asia PublishingHouse.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann EducationalPublishers.
- Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt.Ltd.
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, NewDelhi.

Semester III

PHYSICS-C 5: MATHEMATICAL PHYSICS-II
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

FourierSeries:Periodic functions.Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Even and odd functions and their Fourier expansions. Application. **(10Lectures)**

Frobenius Method and Special Functions: Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of LegendrePolynomials. **(24 Lectures)**

Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. **(4Lectures)**

Theory of Errors: SystematicandRandomErrors.PropagationofErrors.NormalLaw of Errors. Standard and Probable Error. Least-squares fit. **(6Lectures)**

Partial Differential Equations: Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and sphericalsymmetry. **(14Lectures)**

Reference Books:

- MathematicalMethodsforPhysicists:Arfken,Weber,2005,Harris,Elsevier.
- Fourier Analysis by M.R. Spiegel, 2004, TataMcGraw-Hill.
- Mathematics for Physicists, Susan M. Lea, 2004, ThomsonBrooks/Cole.
- Differential Equations, George F. Simmons, 2006, TataMcGraw-Hill.
- PartialDifferentialEquationsforScientists&Engineers,S.J.Farlow,1993,DoverPub.
- EngineeringMathematics,S.PalandS.C.Bhunia,2015,OxfordUniversityPress
- MathematicalmethodsforScientists&Engineers,D.A.McQuarrie,2003,VivaBooks

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PHYSICS - C 5 LAB

60 Lectures

The aim of this Lab is to use the computational methods to solve physical problems. Coursewillconsistoflectures(boththeoryandpractical)intheLab.Evaluationdone notontheprogrammingbutonthebasisofformulatingtheproblem

Topics	**Description with Applications**
Introduction to Numerical computation softwareScilab	Introduction to Scilab, Advantages and disadvantages, Scilab environment, Command window, Figure window,Editwindow,Variablesandarrays,Initialising variables in Scilab, Multidimensional arrays, Subarray, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab functions, Introduction to plotting, 2D and 3D plotting (2), Branching Statements and program design, Relational & logical operators, the while loop, for loop, details of loop operations, break & continuestatements, nested loops, logical arrays and vectorization (2) User defined functions, Introduction to Scilab functions, Variable passing in Scilab, optional arguments, preserving data between calls to a function, Complex and Character data, string function, Multidimensional arrays (2) an introduction to Scilab file processing, file opening and closing, Binary I/o functions, comparing binary and formatted functions, Numerical methodsand developingtheskillsofwritingaprogram(2).
Curve fitting, Least square fit, Goodness of fit, standard deviation	OhmslawtocalculateR,Hooke'slawtocalculatespring constant
Solution of Linear system of equations by Gauss elimination method and Gauss Seidal method. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, eigen values problems	Solutionofmeshequationsofelectriccircuits(3meshes) Solutionofcoupledspringmasssystems(3masses)

Generation of Special functions using User defined functions in Scilab	GeneratingandplottingLegendrePolynomials Generating and plotting Besselfunction
Solution of ODE First order Differential equation Euler, modified Euler and Runge-Kutta second order methods Second order differential equation Fixed difference method Partial differential equations	First order differential equation • Radioactivedecay • Current in RC, LC circuits with DCsource • Newton's law ofcooling • Classical equations of motion Second order DifferentialEquation • Harmonic oscillator (nofriction) • Damped Harmonicoscillator • Overdamped • Criticaldamped • Oscillatory • Forced Harmonicoscillator • Transientand • Steady statesolution • Apply above to LCR circuitsalso • Solve $x^2\frac{d^2y}{ds^2} - 4x(1+x)\frac{dy}{ds} + 2(1+x)y = x^3$ with the boundary conditions at $x = 1, y = \frac{1}{2}e^2, \frac{dy}{dx} = -\frac{3}{2}e^2 - 0.5,$ in the range $1 \le x \le 3$. Plot y and $\frac{dy}{ds}$ against x in the given range on the same graph. Partial Differential Equation: • Wave equation • Heatequation • Poissonequation • Laplaceequation
Using Scicos / xcos	• Generatingsquarewave,sinewave,sawtoothwave • Solution to harmonicoscillator • Study of beatphenomenon • Phase spaceplots

Reference Books:

- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge UniversityPress
- Complex Variables, A.S. Fokas & M.J. Ablowitz, 8th Ed., 2011, Cambridge Univ.Press
- First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones &Bartlett
- Computational Physics, D.Walker, 1st Edn., 2015, Scientific International Pvt.Ltd.
- A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge UniversityPress
- SimulationofODE/PDEModelswithMATLAB®,OCTAVEandSCILAB:Scientific and Engineering Applications: A.V. Wouwer, P. Saucez, C.V. Fernández. 2014 Springer
- Scilab by example: M. Affouf 2012, ISBN:978-1479203444

(Reduced Syllabus for the session 2020-21 only)

- Scilab(AfreesoftwaretoMatlab):H.Ramchandran,A.S.Nair.2011S.Chand&Company
- ScilabImageProcessing:LambertM.Surhone.2010BetascriptPublishing
- www.**scilab**.in/textbook_companion/generate_book/291

PHYSICS-C 6: THERMAL PHYSICS (Credits: Theory-04, Practicals-02) Theory: 60 Lectures

Introduction to Thermodynamics

ZerothandFirstLawofThermodynamics:ExtensiveandintensiveThermodynamic Variables,ThermodynamicEquilibrium,ZerothLawofThermodynamics&Conceptof Temperature,ConceptofWork&Heat,StateFunctions,FirstLawofThermodynamics anditsdifferentialform,InternalEnergy,FirstLaw&variousprocesses,Applicationsof First Law: General Relation between C_P and C_V. **(8Lectures)**

SecondLawofThermodynamics:ReversibleandIrreversibleprocesswithexamples. Conversion of Work intoHeatand HeatintoWork.HeatEngines.Carnot'sCycle, Carnot engine & efficiency. 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. **(10Lectures)**

Entropy: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. **(7Lectures)**

Thermodynamic Potentials: Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. Surface Films and Variation of Surface Tension with Temperature. First and second order Phase Transitions with examples. **(7Lectures)**

Maxwell's Thermodynamic Relations: Derivations and applications of Maxwell's Relations, Maxwell's Relations:(1) Clausius Clapeyron equation, (2) Values of C_p-C_v, **(2)** TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases **(7Lectures)**

Kinetic Theory of Gases

DistributionofVelocities:Maxwell-BoltzmannLawofDistributionofVelocitiesinan Ideal Gas and its Experimental Verification. Mean,RMSandMostProbableSpeeds.DegreesofFreedom.Law of Equipartition of Energy (No proof required). Specific heats of Gases. **(7 Lectures)**

Molecular Collisions: Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and(3)Diffusion. **(4Lectures)**

Real Gases: Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO_2 Gas. Critical Constants. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. P-VDiagrams. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule- Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule- ThomsonCooling. **(10Lectures)**

Reference Books:

- HeatandThermodynamics,M.W.Zemansky,RichardDittman,1981,McGraw-Hill.
- ATreatiseonHeat,MeghnadSaha,andB.N.Srivastava,1958,IndianPress
- ThermalPhysics,S.Garg,R.BansalandGhosh,2nd Edition,1993,TataMcGraw-Hill
- ModernThermodynamicswithStatisticalMechanics,CarlS.Helrich,2009,Springer.
- Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988,Narosa.
- Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford UniversityPress
- ThermalPhysics,A.KumarandS.P.Taneja,2014,R.ChandPublications.

PHYSICS - C 6 LAB

60 Lectures

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flowmethod.
2. TodeterminetheCoefficientofThermalConductivityofCubySearle'sApparatus.
3. TodeterminetheCoefficientofThermalConductivityofCubyAngstrom'sMethod.
4. TodeterminetheCoefficientofThermalConductivityofabadconductorbyLee and Charlton's discmethod.
5. TodeterminetheTemperatureCoefficientofResistancebyPlatinumResistance Thermometer(PRT).
6. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its TwoJunctions.
7. Tocalibrateathermocoupletomeasuretemperatureinaspecified Rangeusing (1) Null Method, (2) Direct measurement using Op-Amp difference amplifier and to determine NeutralTemperature.

Reference Books

- Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia PublishingHouse
- ATextBookofPracticalPhysics,I.Prakash&Ramakrishna,11th Ed.,2011,KitabMahal
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann EducationalPublishers
- ALaboratoryManualofPhysicsforundergraduateclasses,D.P.Khandelwal,1985,VaniPub.

PHYSICS-C7 : DIGITAL SYSTEMS AND APPLICATIONS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Introduction to CRO: Block Diagram of CRO. Electron Gun, Deflection System and Time Base. Deflection Sensitivity. Applications of CRO: (1) Study of Waveform, **(2)** MeasurementofVoltage,Current,Frequency,andPhaseDifference. **(3Lectures)**

Integrated Circuits (Qualitative treatment only): Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration:SSI,MSI,LSI and VLSI(basic idea and definitions only).
(3Lectures)

Digital Circuits: Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. **(6Lectures)**

Boolean algebra: De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2)Karnaugh Map. **(6Lectures)**

Data processing circuits: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders. **(4Lectures)**

Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders.Half &Full Subtractors.
(5 Lectures)

Sequential Circuits: SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. **(6Lectures)**

Timers:IC555:block diagramandapplications:Astable multivibrator. **(3Lectures)**

Shift registers: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers(onlyupto4bits). **(2Lectures)**

Counters(4bits): RingCounter.Asynchronouscounters,DecadeCounter.Synchronous Counter. **(4Lectures)**

ComputerOrganization:Input/OutputDevices.Datastorage(ideaofRAMandROM). Computer memory. Memory organization & addressing. **(6Lectures)**

Intel 8085 Microprocessor Architecture: Main features of 8085. Block diagram. Components.Pin-outdiagram.Buses.Registers.ALU.Memory.Stackmemory.Timing &Controlcircuitry.

(8 Lectures)

Reference Books:

- Digital Principles and Applications, A.P. Malvino, D.P.Leach and Saha, 7th Ed., 2011, TataMcGraw
- Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.
- Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
- Digital Electronics G K Kharate ,2010, Oxford University Press
- Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning
- Logic circuit design, Shimon P. Vingron, 2012, Springer.
- Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
- Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill
- Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.

PHYSICS - C 7 LAB

60 Lectures

1. Tomeasure(a)Voltage,and(b)TimeperiodofaperiodicwaveformusingCRO.
2. To test a Diode and Transistor using aMultimeter.
3. To design a switch (NOT gate) using atransistor.
4. ToverifyanddesignAND,OR,NOTandXORgatesusingNANDgates.
5. TodesignacombinationallogicsystemforaspecifiedTruthTable.
6. ToconvertaBooleanexpressionintologiccircuitanddesignitusinglogicgateICs.
7. To minimize a given logiccircuit.
8. Half Adder, Full Adder and 4-bit binaryAdder.
9. HalfSubtractor,FullSubtractor,Adder-SubtractorusingFullAdderI.C.
10. TobuildFlip-Flop(RS,ClockedRS,D-typeandJK)circuitsusingNANDgates.
11. To build JK Master-slave flip-flop using Flip-FlopICs
12. Tobuilda4-bitCounterusingD-type/JKFlip-FlopICsandstudytimingdiagram.
13. Tomakea4-bitShiftRegister(serialandparallel)usingD-type/JKFlip-FlopICs.
14. Todesignanastablemultivibratorofgivenspecificationsusing555Timer.
15. Todesignamonostablemultivibratorofgivenspecificationsusing555Timer.
16. Write the following programs using 8085Microprocessor
    a) Addition and subtraction of numbers using direct addressingmode

b) Addition and subtraction of numbers using indirect addressingmode
c) Multiplication by repeatedaddition.
d) Division by repeatedsubtraction.
e) Handling of 16-bitNumbers.
f) Use of CALL and RETURNInstruction.
g) Block datahandling.
h) Other programs (e.g. Parity Check, using interrupts,etc.).

Reference Books:

- Modern Digital Electronics, R.P. Jain, 4th Edition, 2010, Tata McGrawHill.
- Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-GrawHill.
- Microprocessor Architecture Programming and applications with 8085, R.S. Goankar, 2002, PrenticeHall.
- Microprocessor 8085:Architecture, Programming and interfacing, A. Wadhwa, 2010, PHILearning.

Skill Enhancement Course (Credit: 02)

SEC - 1: PHYSICS WORKSHOP SKILL
(Credits: 02)
30 Lectures

The aim of this course is to enable the students to familiar and experience with various mechanical and electrical tools through hands-on mode

Introduction: Measuring units. conversion to SI and CGS. Familiarization with meter scale, Vernier calliper, Screw gauge and their utility. Measure the dimension of a solid block, volume of cylindrical beaker/glass, diameter of a thin wire, thickness of metal sheet, etc. (**4 Lectures)**

Mechanical Skill: Concept of workshop practice. Overview of manufacturing methods: casting, foundry, machining, forming and welding. Types of welding joints andweldingdefects.Commonmaterialsusedformanufacturinglikesteel,copper,iron, metal sheets, composites and alloy, wood. Concept of machine processing, introduction to common machine tools like lathe, shaper, drilling, milling and surface machines. **(10Lectures)**

Electrical and Electronic Skill: Use of Multimeter. Soldering of electrical circuits having discrete components(R,L,C,diode)and ICs on PCB. **(10Lectures)**

Introduction to prime movers: Mechanism, gear system, wheel, Fixing of gears with motor axel. Lever mechanism, Lifting of heavy weight using lever. braking systems, pulleys, working principle of power generation systems. **(6Lectures)**

Reference Books:

- AtextbookinElectricalTechnology-BLTheraja–S.ChandandCompany.
- Performance and design of AC machines – M.G. Say, ELBSEdn.
- Mechanical workshop practice, K.C. John, 2010, PHI Learning Pvt.Ltd.
- Workshop Processes, Practices and Materials, Bruce J Black 2005, 3rd Edn., Editor Newnes [ISBN:0750660732]
- New Engineering Technology, Lawrence Smyth/Liam Hennessy, The Educational Company of Ireland [ISBN:0861674480]

GE - 3: THERMAL PHYSICS AND STATISTICAL MECHANICS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Laws of Thermodynamics: Thermodynamic Description of system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between C_P and C_V,Work Done during Isothermal and Adiabatic Processes, Reversible and irreversible processes,
Second law and Entropy, Carnot's cycle & theorem. **(22Lectures)**

Thermodynamical Potentials: Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations. (**10 Lectures)**

Kinetic Theory of Gases: Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case)

(10Lectures)

TheoryofRadiation: Black body radiation, Spectral distribution,Concept of Energy Density,Derivation of Planck'slaw,Deduction of Wien's distributionlaw,Rayleigh-JeansLaw from Planck's Law.

(6 Lectures)

Statistical Mechanics: Phase space, Macrostate and Microstate, Maxwell-Boltzmann law - distribution of velocity - Quantum statistics - Fermi-Dirac distribution law - electron gas. **(12Lectures)**

Reference Books:

- ThermalPhysics,S.Garg,R.BansalandC.Ghosh,1993,TataMcGraw-Hill.
- ATreatiseonHeat,MeghnadSaha,andB.N.Srivastava,1969,IndianPress.
- Thermodynamics, Enrico Fermi, 1956, Courier DoverPublications.
- HeatandThermodynamics,M.W.ZemaskyandR.Dittman,1981,McGrawHill
- Thermodynamics,Kinetictheory&Statisticalthermodynamics,F.W.Searsand G.L. Salinger. 1988, Narosa
- University Physics, Ronald Lane Reese, 2003, ThomsonBrooks/Cole.
- ThermalPhysics,A.KumarandS.P.Taneja,2014,R.chandPublications.

GE -3LAB: THERMAL PHYSICS AND STATISTICAL MECHANICS

60 Lectures

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flowmethod.
2. Measurement of Planck's constant using black bodyradiation.
3. To determine Stefan'sConstant.
4. TodeterminethecoefficientofthermalconductivityofCubySearle'sApparatus.
5. TodeterminetheCoefficientofThermalConductivityofCubyAngstrom'sMethod.
6. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's discmethod.
7. To determine the temperature co-efficient of resistance by Platinum resistance thermometer.
8. Tostudythevariationofthermoemfacrosstwojunctionsofathermocouplewith temperature.
9. To record and analyze the cooling temperature of an hot object as a function of timeusingathermocoupleandsuitabledataacquisitionsystem
10. To calibrate Resistance Temperature Device (RTD) using NullMethod/Off-Balance Bridge.

Reference Books:

- Advanced Practical Physics for students, B.L.Flint & H.T.Worsnop, 1971, Asia PublishingHouse.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann EducationalPublishers
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, NewDelhi.
- ALaboratoryManualofPhysicsforUndergraduateClasses,D.P.Khandelwal, 1985, VaniPublication.

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Semester V

PHYSICS-C 11: QUANTUM MECHANICS AND APPLICATIONS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Time dependent Schrodinger equation: Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; ConditionsforPhysicalAcceptabilityofWaveFunctions.Normalization.Linearityand Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum and Energyoperators; **(6 Lectures)**

Time independent Schrodinger equation-Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wave function as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states. **(10Lectures)**

General discussion of bound states in an arbitrary potential- continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigen functions using Frobenius method. **(12 Lectures)**

Quantum theory of hydrogen-like atoms: time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation;angular momentum operator & quantum numbers;Radial wavefunctions from Frobenius method. **(10 Lectures)**

Atoms in Electric & Magnetic Fields: Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. **(8Lectures)**

Atoms in External Magnetic Fields:-Normal and Anomalous Zeeman Effect. **(4Lectures)**

Manyelectronatoms:Pauli'sExclusionPrinciple.Symmetric&AntisymmetricWave Functions. Periodic table. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum. Vector Model. Spin-orbit coupling in atoms-L-SandJ-Jcouplings.

(10Lectures)

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- **ReferenceBooks:**

- A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed., 2010, McGrawHill
- Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002,Wiley.
- Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGrawHill.
- Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning ofIndia.
- QuantumMechanics,BruceCameronReed,2008,JonesandBartlettLearning.
- Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993,Springer
- Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, PearsonEducation
- Quantum Mechanics, Walter Greiner, 4th Edn., 2001,Springer

PHYSICS - C 11 LAB

60 Lectures

Use C/C^{++}/Scilab for solving the following problems based on Quantum Mechanics like

1. Solvethes-waveSchrodingerequationforthegroundstateandthefirstexcited state of the hydrogenatom:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2N}{k^2}[V(r) - E] \text{ where } V(r) = -\frac{e^2}{r}$$

Here, m is the reduced mass of the electron. Obtain the energy eigenvalues andplot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is ≈ -13.6 eV. Take e = 3.795 (eVÅ)$^{1/2}$, ħc = 1973 (eVÅ) and m = 0.511x10^{6}eV/c^2.

2. Solve the s-wave radial Schrodinger equation for anatom:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2N}{k^2}[V(r) - E]$$

wheremisthereducedmassofthesystem(whichcanbechosentobethemassof an electron), for the screened coulombpotential

$$V(r) = -\frac{e^2}{r}e^{-r/a}$$

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take e = 3.795 (eVÅ)$^{1/2}$, m = 0.511x10^6 eV/c^2, and a = 3 Å, 5 Å, 7 Å. In these units ħc = 1973 (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

3. Solvethes-waveradialSchrodingerequationforaparticleofmassm:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2N}{k^2}[V(r) - E]$$

For the anharmonic oscillator potential

$$V(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3$$

for the ground state energy (in MeV) of particle to an accuracy of three significant digits.Also,plotthecorrespondingwavefunction.Choosem=940MeV/c^2,k=100

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MeV fm^{-2}, b = 0, 10, 30 MeV fm^{-3} In these units, $\hbar c$ = 197.3 MeV fm. The ground state energy I expected to lie between 90 and 110 MeV for all three cases.

4. Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen molecule:

$$\frac{d^2y}{dr^2} = A(r)u(r),\ A(r) = \frac{2\mu}{k^2}[V(r) - E]$$

Where μ is the reduced mass of the two-atom system for the Morse potential

$$V(r) = D(e^{-2\alpha r_F} - e^{-\alpha r_F}), \qquad r_u = \frac{r - r_o}{r}$$

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function.

Take: m = 940×10^6 eV/C^2, D = 0.755501 eV, α = 1.44, r_o = 0.131349 Å

Laboratory based experiments:

5. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency
6. Study of Zeeman effect: with external magnetic field; Hyperfine splitting
7. To show the tunneling effect in tunnel diode using I-V characteristics.
8. Quantum efficiency of CCDs

Reference Books:

- Schaum's outline of Programming with C++. J. Hubbard, 2000, McGraw-Hill Publication
- Numerical Recipes in C: The Art of Scientific Computing, W.H. Press et al., 3rd Edn., 2007, Cambridge University Press.
- An introduction to computational Physics, T. Pang, 2nd Edn., 2006, Cambridge Univ. Press
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A. Vande Wouwer, P. Saucez, C.V. Fernández. 2014 Springer.
- Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand & Co.
- A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
- Scilab Image Processing: L.M. Surhone. 2010 Betascript Publishing ISBN: 978-6133459274

PHYSICS-C 12: SOLID STATE PHYSICS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Crystal Structure: Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis – Central and Non-Central Elements. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor. **(12 Lectures)**

Elementary Lattice Dynamics: Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the

Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids.T^3law **(10Lectures)**

Magnetic Properties of Matter: Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia– and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss.

(8Lectures)

Dielectric Properties of Materials: Polarization. Local Electric Field at an Atom. DepolarizationField.ElectricSusceptibility.Polarizability.ClausiusMosottiEquation. ClassicalTheoryofElectricPolarizability.NormalandAnomalousDispersion.Cauchy andSellmeirrelations.Langevin-Debyeequation.

(8Lectures)

Ferroelectric Properties of Materials: Structural phase transition, Classification of crystals, Piezoelectric effect, Curie-WeissLaw,Ferro electric domains,PE hysteresis loop. **(6lectures)**

Elementarybandtheory: KronigPennymodel.BandGap.Conductor,Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurementofconductivity(04probemethod)&Hallcoefficient. **(10Lectures)**

Reference Books:

- Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt.Ltd.
- Elements of Solid State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice-Hall of India
- Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-GrawHill
- SolidStatePhysics,N.W.AshcroftandN.D.Mermin,1976,CengageLearning
- Solid-state Physics, H. Ibach and H. Luth, 2009,Springer
- Solid State Physics, Rita John, 2014, McGrawHill
- ElementarySolidStatePhysics,1/eM.AliOmar,1999,PearsonIndia
- Solid State Physics, M.A. Wahab, 2011, NarosaPublications

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-PHYSICS - C 12 LAB
60 Lectures

1. Measurementofsusceptibilityofparamagneticsolution(Quinck`sTubeMethod)
2. To measure the Magnetic susceptibility ofSolids.
3. To determine the Coupling Coefficient of a Piezoelectriccrystal.
4. TomeasuretheDielectricConstantofadielectricMaterialswithfrequency
5. Todeterminethecomplexdielectricconstantandplasmafrequencyofmetalusing Surface Plasmon resonance(SPR)
6. To determine the refractive index of a dielectric layer usingSPR
7. To study the PE Hysteresis loop of a FerroelectricCrystal.
8. TodrawtheBHcurveofFeusingSolenoid&determineenergylossfromHysteresis.
9. Tomeasuretheresistivityofasemiconductor(Ge)withtemperaturebyfour-probe method(roomtemperatureto150^{o}C)andtodetermineitsbandgap.
10. To determine the Hall coefficient of a semiconductorsample.

Reference Books

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia PublishingHouse.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann EducationalPublishers.
- ATextBookofPracticalPhysics,I.Prakash&Ramakrishna,11thEd.,2011,KitabMahal
- Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall ofIndia.

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DSE - 1: ADVANCED MATHEMATICAL PHYSICS-I
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Linear Vector Spaces: Abstract Systems. Binary Operations and Relations. Introduction to Groups and Fields. Vector Spaces and Subspaces. Linear Independence andDependenceofVectors.BasisandDimensionsofaVectorSpace.Changeofbasis. Homomorphism and Isomorphism of Vector Spaces. **(12Lectures)**
Matrices: Addition and Multiplication of Matrices. NullMatrices.Diagonal,Scalarand UnitMatrices.Upper-TriangularandLower-TriangularMatrices.TransposeofaMatrix. Symmetric and Skew-Symmetric Matrices. Conjugate of a Matrix. Hermitian andkSew-Hermitian Matrices. Singular and Non-Singular matrices. Orthogonal and Unitary Matrices. **(8Lectures)**
Eigen-values and Eigenvectors. Cayley- Hamiliton Theorem. Diagonalization of Matrices. **(10Lectures)**

CartesianTensors: TransformationofCo-ordinates.Einstein'sSummationConvention. RelationbetweenDirectionCosines.Tensors.AlgebraofTensors.Sum,Differenceand Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetricTensors.InvariantTensors:KroneckerandAlternatingTensors.Association ofAntisymmetricTensorofOrderTwoandVectors.VectorAlgebraandCalculususing Cartesian Tensors : Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation. Gradient, Divergence and Curl of Tensor Fields. Vector Identities. Tensorial Formulation of Analytical Solid Geometry : Equation of a Line. Angle Between Lines. Projection of a Line on another Line. Condition for Two Lines to be Coplanar. **(20lectures)**

GeneralTensors: TransformationofCo-ordinates.MinkowskiSpace.Contravariant& Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors. Algebra of Tensors. Sum, Difference & Product of Two Tensors. **(10Lectures)**

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- **ReferenceBooks:**

- Mathematical Tools for Physics, James Nearing, 2010, DoverPublications
- Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, and F.E. Harris, 1970,Elsevier.
- Modern Mathematical Methods for Physicists and Engineers, C.D. Cantrell, 2011, Cambridge UniversityPress
- IntroductiontoMatricesandLinearTransformations,D.T.Finkbeiner,1978,DoverPub.
- LinearAlgebra,W.Cheney,E.W.Cheney&D.R.Kincaid,2012,Jones&BartlettLearning
- Mathematics for Physicists, Susan M. Lea, 2004, ThomsonBrooks/Cole
- Mathematical Methods for Physicis & Engineers, K.F.Riley, M.P.Hobson, S.J.Bence, 3rd Ed., 2006, Cambridge UniversityPress

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DSE -1 LAB: ADVANCED MATHEMATICAL PHYSICS-I

60 Lectures

Scilab/ C++ based simulations experiments based on Mathematical Physics problems like

1. Linearalgebra:
   - Multiplication of two 3 x 3matrices.
   - Eigenvalue and eigenvectorsof

$$\begin{pmatrix} 2 & 1 & 1 \\ 1 & 3 & 3 \\ 3 & 1 & 3 \end{pmatrix}; \begin{pmatrix} -i & 3+4i & 2 \\ +i & 2 & 4 \\ -4i & 4 & 3 \end{pmatrix}; \begin{pmatrix} -i & 2i \\ 4 & 3 \\ -2i & 3 \end{pmatrix}; \begin{pmatrix} 2i \\ 3 \\ 5 \end{pmatrix}$$

2. Orthogonalpolynomialsaseigenfunctionsof Hermitiandifferentialoperators.
3. Determination of the principal axes of moment of inertia through diagonalization.
4. VectorspaceofwavefunctionsinQuantumMechanics:Positionandmomentum differential operators and their commutator, wave functions for stationary states as eigenfunctions of Hermitian differentialoperator.
5. Lagrangian formulation in Classical Mechanics withconstraints.
6. StudyofgeodesicsinEuclideanandotherspaces(surfaceofasphere,etc).
7. Estimationofgroundstateenergyandwavefunctionofaquantumsystem.

Reference Books:

- SimulationofODE/PDEModelswithMATLAB®,OCTAVEandSCILAB: ScientificandEngineeringApplications:A.VandeWouwer,P.Saucez,C.V. Fernández. 2014 Springer ISBN:978-3319067896
- Scilab by example: M. Affouf, 2012, ISBN:978-1479203444
- ScilabImageProcessing:L.M.Surhone.2010,BetascriptPub.,ISBN:978-6133459274

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DSE - *2*: Nuclear and Particle Physics
(Credits: Theory-05, Tutorials-01)
Theory: 75 Lectures

General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment. **(10Lectures)**

Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model,

(12Lectures)

Radioactivity decay:(a) Alpha decay: basics of α-decay processes, theory of α-emission,(b)β-decay: energy kinematics for β-decay, positron emission, neutrino hypothesis. (c) Gamma decay: Gamma rays emission. (**10Lectures)**

Nuclear Reactions: Types of Reactions, Conservation Laws, kinematics of reactions, Q-value,reactionrate,reactioncrosssection, **(8Lectures)**

Interaction of Nuclear Radiation with matter: Energy loss due to ionization (Bethe-Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter. **(8Lectures)**

Detector for Nuclear Radiations: Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multipliertube(PMT). **(8Lectures)**

Particle Accelerators: Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron,. **(5Lectures)**

Particle physics: Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum,parity, baryon number, Lepton number, Isospin, Strangeness and charm. **(14Lectures)**

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- **ReferenceBooks:**

- IntroductorynuclearPhysicsbyKennethS.Krane(WileyIndiaPvt.Ltd.,2008).
- ConceptsofnuclearphysicsbyBernardL.Cohen.(TataMcgrawHill,1998).
- Introductiontothephysicsofnuclei&particles,R.A.Dunlap.(ThomsonAsia,2004).
- IntroductiontoHighEnergyPhysics,D.H.Perkins,CambridgeUniv.Press
- Introduction to Elementary Particles, D. Griffith, John Wiley &Sons
- QuarksandLeptons,F.HalzenandA.D.Martin,WileyIndia,NewDelhi
- BasicideasandconceptsinNuclearPhysics-AnIntroductoryApproachby K. Heyde (IOP- Institute of Physics Publishing, 2004).
- Radiationdetectionandmeasurement,G.F.Knoll(JohnWiley&Sons,2000).
- PhysicsandEngineeringofRadiationDetection,SyedNaeemAhmed(Academic Press, Elsevier,2007).
- Theoretical Nuclear Physics, J.M. Blatt & V.F.Weisskopf (Dover Pub.Inc.,1991)