CHOICE BASED CREDIT SYSTEM

B. SC. PHYSICAL SCIENCE (PHYSICS, MATHEMATICS, COMPUTER SCIENCE)
## Details of Courses Under Undergraduate Program (B.Sc.)

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I. Core Course</strong></td>
<td></td>
</tr>
<tr>
<td>(12 Papers)</td>
<td></td>
</tr>
<tr>
<td>04 Courses from each of the 03 disciplines of choice</td>
<td></td>
</tr>
<tr>
<td>Core Course Practical / Tutorial*</td>
<td>12X2=24</td>
</tr>
<tr>
<td>(12 Practical/ Tutorials*)</td>
<td></td>
</tr>
<tr>
<td>04 Courses from each of the 03 Disciplines of choice</td>
<td></td>
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<tr>
<td><strong>II. Elective Course</strong></td>
<td></td>
</tr>
<tr>
<td>(6 Papers)</td>
<td></td>
</tr>
<tr>
<td>Two papers from each discipline of choice including paper of interdisciplinary nature.</td>
<td></td>
</tr>
<tr>
<td>Elective Course Practical / Tutorials*</td>
<td>6 X 2=12</td>
</tr>
<tr>
<td>(6 Practical / Tutorials*)</td>
<td></td>
</tr>
<tr>
<td>Two Papers from each discipline of choice including paper of interdisciplinary nature</td>
<td></td>
</tr>
<tr>
<td>• Optional Dissertation or project work in place of one Discipline elective paper (6 credits) in 6th Semester</td>
<td></td>
</tr>
</tbody>
</table>
III. Ability Enhancement Courses

1. Ability Enhancement Compulsory

(2 Papers of 2 credits each)
- Environmental Science
- English/MIL Communication

2. Skill Enhancement Course

(Skill Based)

(4 Papers of 2 credits each)

Total credit= 120

Institute should evolve a system/policy about ECA/ General Interest/Hobby/Sports/NCC/NSS/related courses on its own.

*wherever there is practical there will be no tutorials and vice-versa
## Proposed scheme for choice based credit system in B. Sc. Physical Science

<table>
<thead>
<tr>
<th>CORE COURSE (12)</th>
<th>Ability Enhancement Compulsory Course (AECC) (2)</th>
<th>Skill Enhancement Course (SEC) (2)</th>
<th>Discipline Specific Elective DSE (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Mechanics</td>
<td>(English/MIL Communication)/ Environmental Science</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Differential Calculus</td>
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<tr>
<td></td>
<td>Object Oriented Programming in C++</td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>Electricity, Magnetism and EMT</td>
<td>Environmental Science /(English/MIL Communication)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Differential Equations</td>
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</tr>
<tr>
<td></td>
<td>Data Structures and File Processing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>Thermal Physics and Statistical Mechanics</td>
<td></td>
<td>SEC-1</td>
</tr>
<tr>
<td></td>
<td>Real Analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Numerical Computing</td>
<td></td>
<td>SEC-2</td>
</tr>
<tr>
<td>IV</td>
<td>Waves and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subject</td>
<td>SEC</td>
<td>DSE</td>
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<td>-------------------------------------</td>
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<td></td>
</tr>
<tr>
<td>Optics</td>
<td>V</td>
<td>SEC -3</td>
<td>DSE-1 A</td>
</tr>
<tr>
<td>Algebra</td>
<td>VI</td>
<td>SEC -4</td>
<td>DSE-1 B</td>
</tr>
<tr>
<td>Design and Analysis of Algorithms</td>
<td></td>
<td></td>
<td>DSE-2 B</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DSE-3 B</td>
</tr>
<tr>
<td>SEMESTER</td>
<td>COURSE OPTED</td>
<td>COURSE NAME</td>
<td>Credits</td>
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</tr>
<tr>
<td>I</td>
<td>Ability Enhancement Compulsory Course-I</td>
<td>English/MIL communications/ Environmental Science</td>
<td>2</td>
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<tr>
<td></td>
<td>Core course-I</td>
<td>Mechanics</td>
<td>4</td>
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<tr>
<td></td>
<td>Core Course-I Practical/Tutorial</td>
<td>Mechanics Lab</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Core course-II</td>
<td>Differential Calculus</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Core Course-III</td>
<td>Object Oriented Programming in C++</td>
<td>6</td>
</tr>
<tr>
<td>II</td>
<td>Ability Enhancement Compulsory Course-II</td>
<td>English/MIL communications/ Environmental Science</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Core course-IV</td>
<td>Electricity, Magnetism and EMT</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Core Course-IV Practical/Tutorial</td>
<td>Electricity, Magnetism and EMT Lab</td>
<td>2</td>
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<tr>
<td></td>
<td>Core course-V</td>
<td>Differential Equations</td>
<td>6</td>
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<tr>
<td></td>
<td>Core Course-VI</td>
<td>Data Structures and File Processing</td>
<td>6</td>
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<tr>
<td>III</td>
<td>Core course-VII</td>
<td>Thermal Physics and Statistical Mechanics</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Core Course-VII Practical/Tutorial</td>
<td>Thermal Physics and Statistical Mechanics Lab</td>
<td>2</td>
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<tr>
<td></td>
<td>Core course-VIII</td>
<td>Real Analysis</td>
<td>6</td>
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<tr>
<td></td>
<td>Core Course-IX</td>
<td>Numerical Computing</td>
<td>6</td>
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<tr>
<td></td>
<td>Skill Enhancement Course -1</td>
<td>SEC-1</td>
<td>2</td>
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<tr>
<td>IV</td>
<td>Core course-X</td>
<td>Waves and Optics</td>
<td>4</td>
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<tr>
<td></td>
<td>Course-X Practical/Tutorial</td>
<td>Waves and Optics Lab</td>
<td>2</td>
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<tr>
<td></td>
<td>Core course-XI</td>
<td>Algebra</td>
<td>6</td>
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<tr>
<td></td>
<td>Core course-XII</td>
<td>Design and Analysis of Algorithms</td>
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<td></td>
<td>Skill Enhancement Course -2</td>
<td>SEC -2</td>
<td>2</td>
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<tr>
<td>V</td>
<td>Skill Enhancement Course -3</td>
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<td>Discipline Specific Elective -1</td>
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<td>Discipline Specific Elective -2</td>
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<td>Discipline Specific Elective -3</td>
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<td>6</td>
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<tr>
<td>VI</td>
<td>Skill Enhancement Course -4</td>
<td>SEC -4</td>
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</tr>
<tr>
<td></td>
<td>Discipline Specific Elective -4</td>
<td>DSE-1B</td>
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<td></td>
<td>Discipline Specific Elective -5</td>
<td>DSE-2B</td>
<td>6</td>
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<td></td>
<td>Discipline Specific Elective-6</td>
<td>DSE-3B</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td><strong>Total Credits</strong></td>
<td></td>
<td><strong>120</strong></td>
</tr>
</tbody>
</table>
B.Sc. Physical Science

PHYSICS
Core papers Physics (Credit: 06 each) (CP 1-4):

1. Mechanics (4) + Lab (4)
2. Electricity and Magnetism (4) + Lab (4)
3. Thermal Physics and Statistical Mechanics (4) + Lab (4)
4. Waves and Optics (4) + Lab (4)

Discipline Specific Elective papers (Credit: 06 each) (DSE 1, DSE 2): Choose 2

1. Digital, Analog and Instrumentation (4) + Lab (4)
2. Elements of Modern Physics (4) + Lab (4)
3. Mathematical Physics (4) + Lab (4)
4. Solid State Physics (4) + Lab (4)
5. Quantum Mechanics (4) + Lab (4)
6. Embedded System: Introduction to microcontroller (4) + Lab (4)
7. Nuclear and Particle Physics (5) + Tut (1)
8. Medical Physics (4) + Lab (4)
9. Dissertation

Note: Universities may include more options or delete some from this list

Skill Enhancement Course (any four) (Credit: 02 each)- SEC 1 to SEC 4

1. Physics Workshop Skills
2. Computational Physics Skills
3. Electrical circuits and Network Skills
4. Basic Instrumentation Skills
5. Renewable Energy and Energy harvesting
6. Technical Drawing
7. Radiology and Safety
8. Applied Optics
9. Weather Forecasting

Note: Universities may include more options or delete some from this list

Important:

1. Each University/Institute should provide a brief write-up about each paper outlining the salient features, utility, learning objectives and prerequisites.
2. University/Institute can add/delete some experiments of similar nature in the Laboratory papers.
3. The size of the practical group for practical papers is recommended to be 12-15 students.
4. University/Institute can add to the list of reference books given at the end of each paper.
PHYSICS-DSC 1 A: MECHANICS  
(Credits: Theory-04, Practicals-02)  
Theory: 60 Lectures

**Vectors**: Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter.  
(4 Lectures)

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

(10 Lectures)

(6 Lectures)

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

(8 Lectures)

(6 Lectures)

**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 - Work done in stretching and work done in twisting a wire - Twisting couple on a cylinder - Determination of Rigidity modulus by static torsion - Torsional pendulum-Determination of Rigidity modulus and moment of inertia - q, η and oby Searles method  
(8 Lectures)

(7 Lectures)
Note: Students are not familiar with vector calculus. Hence all examples involve differentiation either in one dimension or with respect to the radial coordinate.

Reference Books:
• University Physics. FW Sears, MW Zemansky and HD Young13/e, 1986. Addison-Wesley
• Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley
• Engineering Mechanics, Basudeb Bhattacharya, 2nd edn., 2015, Oxford University Press
• University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

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PHYSICS LAB: DSC 1

A LAB:

60 Lectures

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To determine the Height of a Building using a Sextant.
3. To determine the Moment of Inertia of a Flywheel.
4. To determine the Young's Modulus of a Wire by Optical Lever Method.
5. To determine the Modulus of Rigidity of a Wire by Maxwell’s needle.
6. To determine the Elastic Constants of a Wire by Searle’s method.
7. To determine g by Bar Pendulum.
8. To determine g by Kater’s Pendulum.
9. To determine g and velocity for a freely falling body using Digital Timing Technique
10. To study the Motion of a Spring and calculate (a) Spring Constant (b) Value of g

Reference Books:
• Advanced Practical Physics for students, B.L.Flint and H.T.Worsnop, 1971, Asia Publishing House.
• Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd.

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Semester II
PHYSICS-DSC 2A: ELECTRICITY AND MAGNETISM  
(Credits: Theory-04, Practicals-02)  
Theory: 60 Lectures

Vector Analysis: Review of vector algebra (Scalar and Vector product), gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only).  
(12 Lectures)

Electrostatics: Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric.  
(22 Lectures)

Magnetism:  
(10 Lectures)

(6 Lectures)

Maxwell`s equations and Electromagnetic wave propagation: Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves, polarization.  
(10 Lectures)

Reference Books:  
• Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education.  
• Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.  
• University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
PHYSICS LAB- DSC 2A LAB: ELECTRICITY AND MAGNETISM

60 Lectures

1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, and (d) checking electrical fuses.

2. Ballistic Galvanometer:
   (i) Measurement of charge and current sensitivity
   (ii) Measurement of CDR
   (iii) Determine a high resistance by Leakage Method
   (iv) To determine Self Inductance of a Coil by Rayleigh’s Method.

3. To compare capacitances using De’Sauty’s bridge.


5. To study the Characteristics of a Series RC Circuit.

6. To study the a series LCR circuit and determine its (a) Resonant Frequency, (b) Quality Factor.

7. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.

8. To determine a Low Resistance by Carey Foster’s Bridge.

9. To verify the Thevenin and Norton theorem

10. To verify the Superposition, and Maximum Power Transfer Theorem

Reference Books

- Advanced Practical Physics for students, B.L. Flint & H.T. Worsnop, 1971, Asia Publishing House.
- Engineering Practical Physics, S. Panigrahi & B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
Semester III

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

Laws of Thermodynamics:

(22 Lectures)

Thermodynamic Potentials: Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell’s relations & applications - Joule-Thompson Effect, Clausius-Clapeyron Equation, Expression for $(C_p - C_V)$, $C_p/C_V$, $TdS$ equations.  

(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), Law of equipartition of energy (no derivation) and its applications to specific heat of gases; mono-atomic and diatomic gases.  

(10 Lectures)


(6 Lectures)


(12 Lectures)

Reference Books:
• A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.
• Thermodynamics, Enrico Fermi, 1956, Courier Dover Publications.
PHYSICS LAB-DSC 3A LAB: THERMAL PHYSICS AND STATISTICAL MECHANICS

60 Lectures
1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne’s constant flow method.
3. To determine Stefan’s Constant.
4. To determine the coefficient of thermal conductivity of copper by Searle’s Apparatus.
5. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom’s Method.
6. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton’s disc method.
7. To determine the temperature co-efficient of resistance by Platinum resistance thermometer.
8. To study the variation of thermo emf across two junctions of a thermocouple with temperature.
9. To record and analyze the cooling temperature of an hot object as a function of time using a thermocouple and suitable data acquisition system.
10. To calibrate Resistance Temperature Device (RTD) using Null Method/Off-Balance Bridge

Reference Books:

- Advanced Practical Physics for students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House.
PHYSICS-DSC 4A: WAVES AND OPTICS
(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

**Superposition of Two Collinear Harmonic oscillations**: Linearity and Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats). *(4 Lectures)*

**Superposition of Two Perpendicular Harmonic Oscillations**: Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses. *(2 Lectures)*

**Waves Motion - General**: Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves. Spherical waves, Wave intensity. *(7 Lectures)*

**Fluids**: Surface Tension: Synclastic and anticlastic surface - Excess of pressure - Application to spherical and cylindrical drops and bubbles - variation of surface tension with temperature - Jaeger’s method. Viscosity: Viscosity - Rate flow of liquid in a capillary tube - Poiseille’s formula - Determination of coefficient of viscosity of a liquid - Variations of viscosity of a liquid with temperature lubrication. Physics of low pressure - production and measurement of low pressure - Rotary pump - Diffusion pump - Molecular pump - Knudsen absolute gauge - penning and pirani gauge – Detection of leakage. *(6 Lectures)*

**Sound**: Simple harmonic motion - forced vibrations and resonance - Fourier’s Theorem - Application to saw tooth wave and square wave - Intensity and loudness of sound - Decibels - Intensity levels - musical notes - musical scale. Acoustics of buildings: Reverberation and time of reverberation - Absorption coefficient - Sabine’s formula - measurement of reverberation time - Acoustic aspects of halls and auditoria. *(6 Lectures)*


**Michelson’s Interferometer**: Idea of form of fringes (no theory needed). Determination of wavelength, Wavelength difference, Refractive index and Visibility of fringes. *(3 Lectures)*

**Polarization:** Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization. (5 Lectures)

**Reference Books:**
- Principles of Optics, B.K. Mathur, 1995, Gopal Printing
- University Physics. FW Sears, MW Zemansky and HD Young 13/e, 1986. Addison-Wesley

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**PHYSICS LAB-DSC 4A LAB: WAVES AND OPTICS**

60 Lectures

1. To investigate the motion of coupled oscillators
2. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde’s Experiment and to verify $\lambda^2 - T$ Law.
3. To study Lissajous Figures
4. Familiarization with Schuster’s focussing; determination of angle of prism.
5. To determine the Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille’s method).
6. To determine the Refractive Index of the Material of a given Prism using Sodium Light.
7. To determine Dispersive Power of the Material of a given Prism using Mercury Light
8. To determine the value of Cauchy Constants of a material of a prism.
10. To determine wavelength of sodium light using Fresnel Biprism.
12. To determine the wavelength of Laser light using Diffraction of Single Slit.
13. To determine wavelength of (1) Sodium & (2) spectrum of Mercury light using plane diffraction Grating
15. To measure the intensity using photosensor and laser in diffraction patterns of single and double slits.

**Reference Books:**
- Advanced Practical Physics for students, B.L. Flint & H.T. Worsnop, 1971, Asia Publishing House.
Discipline Specific Elective
Select two papers

PHYSICS- DSE: DIGITAL AND ANALOG CIRCUITS AND INSTRUMENTATION
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

UNIT-1: Digital Circuits

(4 Lectures)


(5 Lectures)


(4 Lectures)

UNIT-2: Semiconductor Devices and Amplifiers:

(5 Lectures)


UNIT-3: Operational Amplifiers (Black Box approach):

Sinusoidal Oscillators: Barkhausen's Criterion for Self-sustained Oscillations. Determination of Frequency of RC Oscillator (5 Lectures)

UNIT-4: Instrumentations:
Introduction to CRO: Block Diagram of CRO. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference. (3 Lectures)

Power Supply: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers Calculation of Ripple Factor and Rectification Efficiency, Basic idea about capacitor filter, Zener Diode and Voltage Regulation (6 Lectures)

Timer IC: IC 555 Pin diagram and its application as Astable & Monostable Multivibrator (3 Lectures)

Reference Books:
• Electronic devices and circuits, S. Salivahanan and N. Suresh Kumar, 2012, Tata Mc-Graw Hill.
• Modern Electronic Instrumentation & Measurement Tech., Helfrick&Cooper,1990, PHI Learning
• OP-AMP and Linear Digital Circuits, R.A. Gayakwad, 2000, PHI Learning Pvt. Ltd.

PRACTICALS - DSE LAB: DIGITAL AND ANALOG CIRCUITS AND INSTRUMENTS
60 Lectures
1. To measure (a) Voltage, and (b) Frequency of a periodic waveform using a CRO
2. To verify and design AND, OR, NOT and XOR gates using NAND gates.
3. To minimize a given logic circuit.
4. Half adder, Full adder and 4-bit Binary Adder.
5. Adder-Subtractor using Full Adder I.C.
6. To design an astable multivibrator of given specifications using 555 Timer.
7. To design a monostable multivibrator of given specifications using 555 Timer.
8. To study IV characteristics of PN diode, Zener and Light emitting diode
9. To study the characteristics of a Transistor in CE configuration.
10. To design a CE amplifier of a given gain (mid-gain) using voltage divider bias.
11. To design an inverting amplifier of a given gain using Op-amp 741 and study its frequency response.
12. To design a non-inverting amplifier of a given gain using Op-amp 741 and study its Frequency Response.
14. To investigate the use of an op-amp as a Differentiator
15. To design a Wien Bridge Oscillator using an op-amp.

Reference Books:

PHYSICS- DSE: ELEMENTS OF MODERN PHYSICS
(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Planck’s quantum, Planck’s constant and light as a collection of photons; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. (8 Lectures)

Problems with Rutherford model- instability of atoms and observation of discrete atomic spectra; Bohr's quantization rule and atomic stability; calculation of energy levels for hydrogen like atoms and their spectra. (4 Lectures)

Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle. (4 Lectures)

Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical
interpretation of wavefunction, probabilities and normalization; Probability and probability current densities in one dimension.  

One dimensional infinitely rigid box - energy eigenvalues and eigenfunctions, normalization; Quantum dot as an example; Quantum mechanical scattering and tunnelling in one dimension - across a step potential and across a rectangular potential barrier.  

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, semi-empirical mass formula and binding energy.  

Radioactivity: stability of nucleus; Law of radioactive decay; Mean life & half-life; α decay; β decay - energy released, spectrum and Pauli's prediction of neutrino; γ-ray emission.  

Fission and fusion - mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions.  

Reference Books:  
- Six Ideas that Shaped Physics: Particle Behave like Waves, Thomas A. Moore, 2003, McGraw Hill  

PRACTICALS - DSE-1 LAB: ELEMENTS OF MODERN PHYSICS  
60 Lectures  

1. To determine value of Boltzmann constant using V-I characteristic of PN diode.  
2. To determine work function of material of filament of directly heated vacuum diode.  
3. To determine value of Planck’s constant using LEDs of at least 4 different colours.  
4. To determine the ionization potential of mercury.  
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.  
6. To determine the absorption lines in the rotational spectrum of Iodine vapour.
7. To study the diffraction patterns of single and double slits using laser source and measure its intensity variation using Photosensor and compare with incoherent source – Na light.

8. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light

9. To determine the value of e/m by magnetic focusing.

10. To setup the Millikan oil drop apparatus and determine the charge of an electron.

**Reference Books:**

- Advanced Practical Physics for students, B.L. Flint & H.T. Worsnop, 1971, Asia Publishing House.

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**PHYSICS-DSE: MATHEMATICAL PHYSICS**

*(Credits: Theory-04, Practicals-02)*

**Theory: 60 Lectures**

The emphasis of the course is on applications in solving problems of interest to physicists. The students are to be examined entirely on the basis of problems, seen and unseen.

**Calculus of functions of more than one variable:** Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers.  

* (6 Lectures)  


* (10 Lectures)  


* (16 Lectures)  

**Some Special Integrals:** Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral).  

* (4 Lectures)

(10 Lectures)


(14 Lectures)

Reference Books:
• An Introduction to Ordinary Differential Equations, Earl A Coddington, 1961, PHI Learning.
• Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
• Essential Mathematical Methods, K.F. Riley and M.P. Hobson, 2011, Cambridge University Press

PRACTICALS - DSE LAB: MATHEMATICAL PHYSICS
60 Lectures

The aim of this course is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.
• Highlights the use of computational methods to solve physical problems
• Use of computer language as a tool in solving physics problems (applications)
• The course will consist of lectures (both theory and practical) in the Computer Lab
• Evaluation done not on the programming but on the basis of formulating the problem
• Aim at teaching students to construct the computational problem to be solved
• Students can use anyone operating system Linux or Microsoft Windows

<table>
<thead>
<tr>
<th>Topics</th>
<th>Description with Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction and Overview</td>
<td>Computer architecture and organization, memory and Input/output devices</td>
</tr>
<tr>
<td>Topic</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Basics of scientific computing</td>
<td>Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow &amp; overflow- emphasize the importance of making equations in terms of dimensionless variables, Iterative methods</td>
</tr>
<tr>
<td>Errors and error Analysis</td>
<td>Truncation and round off errors, Absolute and relative errors, Floating point computations.</td>
</tr>
<tr>
<td>Review of C &amp; C++ Programming fundamentals</td>
<td>Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping statements) (If-statement, If-else Statement, Nested if Structure, Else-if Statement, Ternary Operator, Goto Statement, Switch Statement, Unconditional and Conditional Looping, While-Loop, Do-While Loop, FOR Loop, Break and Continue Statements, Nested Loops), Arrays (1D&amp;2D) and strings, user defined functions, Structures and Unions, Idea of classes and objects</td>
</tr>
<tr>
<td>Programs: using C/C++ language</td>
<td>Sum &amp; average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending-descending order, Binary search</td>
</tr>
<tr>
<td>Random number generation</td>
<td>Area of circle, area of square, volume of sphere, value of pi (π)</td>
</tr>
<tr>
<td>Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods</td>
<td>Solution of linear and quadratic equation, solving ( \alpha = \tan \alpha ); ( I = I_0 \left( \frac{\sin \alpha}{\alpha} \right)^2 ) in optics</td>
</tr>
<tr>
<td>Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation</td>
<td>Evaluation of trigonometric functions e.g. ( \sin \theta, \cos \theta, \tan \theta ), etc.</td>
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<tr>
<td>Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method</td>
<td>Given Position with equidistant time data to calculate velocity and acceleration and vice-versa. Find the area of B-H Hysteresis loop</td>
</tr>
</tbody>
</table>
Solution of Ordinary Differential Equations (ODE)

First order Differential equation Euler, modified Euler and Runge-Kutta (RK) second and fourth order methods

First order differential equation
- Radioactive decay
- Current in RC, LC circuits with DC source
- Newton's law of cooling
- Classical equations of motion

Attempt following problems using RK 4 order method:
- Solve the coupled differential equations
  \[
  \frac{dx}{dt} = y + x - \frac{x^3}{3} ; \quad \frac{dy}{dx} = -x
  \]
  for four initial conditions
  \[x(0) = 0, y(0) = -1, -2, -3, -4.\]
  Plot x vs y for each of the four initial conditions on the same screen for \(0 \leq t \leq 15\)

The differential equation describing the motion of a pendulum is \(\frac{d^2\theta}{dt^2} = -\sin(\theta)\). The pendulum is released from rest at an angular displacement \(\alpha\), i.e. \(\theta(0) = \alpha\) and \(\theta(0) = 0\). Solve the equation for \(\alpha = 0.1, 0.5\) and 1.0 and plot \(\theta\) as a function of time in the range \(0 \leq t \leq 8\pi\). Also plot the analytic solution valid for small \(\theta\) \((\sin(\theta) = \theta)\)

Reference Books:
- A first course in Numerical Methods, Uri M. Ascher and Chen Greif, 2012, PHI Learning
- An Introduction to Computational Physics, T. Pang, 2nd Edn., 2006, Cambridge Univ. Press

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PHYSICS-DSE: SOLID STATE PHYSICS
(Credits: Theory-04, Practicals-02)
**Theory: 60 Lectures**


(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. $T^3$ law

(10 Lectures)


(12 Lectures)


(10 Lectures)


(10 Lectures)


(6 Lectures)

**Reference Books:**
- Introduction to Solid State Physics, Charles Kittel, 8th Ed., 2004, Wiley India Pvt. Ltd.
• Solid-state Physics, H. Ibach and H Luth, 2009, Springer
• Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
• Solid State Physics, M.A. Wahab, 2011, Narosa Publications

PRACTICALS-DSE LAB: SOLID STATE PHYSICS

60 Lectures
1. Measurement of susceptibility of paramagnetic solution (Quinck’s Tube Method)
2. To measure the Magnetic susceptibility of Solids.
3. To determine the Coupling Coefficient of a Piezoelectric crystal.
4. To measure the Dielectric Constant of a dielectric Materials with frequency
5. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)
6. To determine the refractive index of a dielectric layer using SPR
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.
8. To draw the BH curve of iron using a Solenoid and determine the energy loss from Hysteresis.
9. To measure the resistivity of a semiconductor (Ge) crystal with temperature by four-probe method (from room temperature to 150 °C) and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.

Reference Books
• Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
• A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Ed., 2011, Kitab Mahal, New Delhi
• Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India

PHYSICS-DSE: QUANTUM MECHANICS

(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; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and
Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum & Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle.  

(6 Lectures)

**Time independent Schrodinger equation**-Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to the spread of Gaussian wavepacket for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle.  

(10 Lectures)

**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 eigenfunctions using Frobenius method.  

(12 Lectures)

**Quantum theory of hydrogen-like atoms**: time independent Schrodinger equation in spherical polar coordinates; separation of variables for the second order partial differential equation; angular momentum operator and quantum numbers; Radial wavefunctions from Frobenius method; Orbital angular momentum quantum numbers l and m; s, p, d.. shells (idea only)  

(10 Lectures)


(8 Lectures)

**Atoms in External Magnetic Fields**: Normal and Anomalous Zeeman Effect.  

(4 Lectures)


(10 Lectures)

**Reference Books**:  
- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
PRACTICAL-DSE LAB: QUANTUM MECHANICS

60 Lectures

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

1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom:

\[ \frac{d^2\psi}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2} [V(r) - E] \] where \( V(r) = -\frac{e^2}{r} \)

Here, \( m \) is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is \( \approx -13.6 \) eV. Take \( e = 3.795 \) (eV Å)^{1/2}, \( \hbar c = 1973 \) (eV Å) and \( m = 0.511 \times 10^6 \) eV/c^2.

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

\[ \frac{d^2\psi}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2} [V(r) - E] \]

Where \( m \) is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened coulomb potential

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

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 \( e = 3.795 \) (eV Å)^{1/2}, \( m = 0.511 \times 10^6 \) eV/c^2, and \( a = 3 \) Å, 5 Å, 7 Å. In these units \( \hbar c = 1973 \) (eV Å). The ground state energy is expected to be above -12 eV in all three cases.

3. Solve the s-wave radial Schrodinger equation for a particle of mass \( m \):

\[ \frac{d^2\psi}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2} [V(r) - E] \]

For the anharmonic oscillator potential
\[
V(r) = \frac{1}{2} k r^2 + \frac{1}{3} b r^3
\]

for the ground state energy (in MeV) of the particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose \(m = 940\) MeV/c², \(k = 100\) MeV fm\(^{-2}\), \(b = 0, 10, 30\) MeV fm\(^{-3}\) in these units, \(\hbar = 197.3\) 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 Schrödinger equation for the vibrations of hydrogen molecule:

\[
\frac{d^2 \psi}{dr^2} = A(r)u(r),\quad A(r) = \frac{2\mu}{\hbar^2} [V(r) - E]
\]

where \(\mu\) is the reduced mass of the two-atom system for the Morse potential

\[
V(r) = D(e^{-2\alpha r'} - e^{-\alpha r'}),\quad r' = \frac{r - r_0}{r_0}
\]

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

Take: \(m = 940\times10^6\) eV/C², \(D = 0.755501\) eV, \(\alpha = 1.44\), \(r_0 = 0.131349\) 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 study the quantum tunnelling effect with solid state device, e.g. tunnelling current in backward diode or tunnel diode.

Reference Books:

- Scilab by example: M. Affouf2012ISBN: 978-1479203444
- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
PHYSICS-DSE: EMBEDDED SYSTEM: INTRODUCTION TO MICROCONTROLLERS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Embedded system introduction: Introduction to embedded systems and general purpose computer systems, architecture of embedded system, classifications, applications and purpose of embedded systems, challenges and design issues in embedded systems, operational and non-operational quality attributes of embedded systems, elemental description of embedded processors and microcontrollers.

(6 Lectures)

Review of microprocessors: Organization of Microprocessor based system, 8085µp pin diagram and architecture, concept of data bus and address bus, 8085 programming model, instruction classification, subroutines, stacks and its implementation, delay subroutines, hardware and software interrupts.

(4 Lectures)

8051 microcontroller: Introduction and block diagram of 8051 microcontroller, architecture of 8051, overview of 8051 family, 8051 assembly language programming, Program Counter and ROM memory map, Data types and directives, Flag bits and Program Status Word (PSW) register, Jump, loop and call instructions.

(12 Lectures)


(4 Lectures)

Programming of 8051: 8051 addressing modes and accessing memory using various addressing modes, assembly language instructions using each addressing mode, arithmetic & logic instructions, 8051 programming in C:- for time delay and I/O operations and manipulation, for arithmetic & logic operations, for ASCII and BCD conversions.

(12 Lectures)

Timer and counter programming: Programming 8051 timers, counter programming.

(3 Lectures)

Serial port programming with and without interrupt: Introduction to 8051 interrupts, programming timer interrupts, programming external hardware interrupts and serial communication interrupt, interrupt priority in the 8051.

(6 Lectures)

Interfacing 8051 microcontroller to peripherals: Parallel and serial ADC, DAC interfacing, LCD interfacing.

(2 Lectures)
Programming Embedded Systems: Structure of embedded program, infinite loop, compiling, linking and locating, downloading and debugging.

(3 Lectures)

Embedded system design and development: Embedded system development environment, file types generated after cross compilation, disassembler/decompiler, simulator, emulator and debugging, embedded product development life-cycle, trends in embedded industry.

(8 Lectures)

Reference Books:
- Embedded Systems: Design & applications, 1/e S.F. Barrett, 2008, Pearson Education India
- Embedded Microcomputer systems: Real time interfacing, J.W.Valvano 2011,Cengage Learning

PRACTICALS- DSE LAB: EMBEDDED SYSTEM: INTRODUCTION TO MICROCONTROLLERS
60 Lectures

Following experiments using 8051:

1. To find that the given numbers is prime or not.
2. To find the factorial of a number.
3. Write a program to make the two numbers equal by increasing the smallest number and decreasing the largest number.
4. Use one of the four ports of 8051 for O/P interfaced to eight LED’s. Simulate binary counter (8 bit) on LED’s.
5. Program to glow first four LED then next four using TIMER application.
6. Program to rotate the contents of the accumulator first right and then left.
7. Program to run a countdown from 9-0 in the seven segment LED display.
8. To interface seven segment LED display with 8051 microcontroller and display ‘HELP’ in the seven segment LED display.
9. To toggle ‘1234’ as ‘1324’ in the seven segment LED.
10. Interface stepper motor with 8051 and write a program to move the motor through a given angle in clock wise or counter clockwise direction.
11. Application of embedded systems: Temperature measurement, some information on LCD display, interfacing a keyboard.
Reference Books:
- Embedded Microcomputer systems: Real time interfacing, J.W.Valvano 2011,Cengage Learning

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PHYSICS-DSE: Nuclear & Particle Physics

(Credits: Theory-05, Tutorials-01)

Theory: 75 Lectures

General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, quantitative facts about size, mass, charge density (matter energy), 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, electric moments, nuclear excites states. (10 Lectures)

Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of various terms, condition of nuclear stability. Two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force. (12 Lectures)

Radioactivity decay:(a) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b) β-decay: energy kinematics for β-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion. (10 Lectures)

Nuclear Reactions: Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct reaction, resonance reaction, Coulomb scattering (Rutherford scattering). (8 Lectures)

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, photoelectric effect, Compton scattering, pair production, neutron interaction with matter. (8 Lectures)

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-multiplier tube (PMT). Semiconductor Detectors (Si & Ge) for charge particle and photon detection (concept of charge carrier and mobility).

(8 Lectures)

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

(5 Lectures)

**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, concept of quark model, color quantum number and gluons.

(14 Lectures)

Reference Books:

- Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
- Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
- Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi
- Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).

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**PHYSICS-DSE:** Medical Physics

*(Credits: Theory-04, Practicals-02)*

**Theory:** 60 Lectures

**PHYSICS OF THE BODY-I**  
**Energy household of the body:** Energy balance in the body, Energy consumption of the body, Heat losses of the body, Thermal Regulation.  
**Pressure system of body:** Physics of breathing, Physics of cardiovascular system.  

(8 Lectures)

**PHYSICS OF THE BODY-II**  
**Acoustics of the body:** Nature and characteristics of sound, Production of speech, Physics of the ear, Diagnostics with sound and ultrasound.  
**Optical system of the body:** Physics of the eye.  
**Electrical system of the body:** Physics of the nervous system, Electrical signals and information transfer.  

(10 Lectures)
PHYSICS OF DIAGNOSTIC AND THERAPEUTIC SYSTEMS-I

X-RAYS: Electromagnetic spectrum, production of x-rays, x-ray spectra, Brehmsstrahlung, Characteristic x-ray. **X-ray tubes & types**: Coolidge tube, x-ray tube design, tube cooling stationary mode, Rotating anode x-ray tube, Tube rating, quality and intensity of x-ray. X-ray generator circuits, half wave and full wave rectification, filament circuit, kilo voltage circuit, types of X-Ray Generator, high frequency generator, exposure timers and switches, HT cables, HT generation. (7 Lectures)

RADIATION PHYSICS: Radiation units exposure, absorbed dose, units: rad, gray, relative biological effectiveness, effective dose, inverse square law. Interaction of radiation with matter Compton & photoelectric effect, Rem & Sievert, linear attenuation coefficient. **Radiation Detectors**: Thimble chamber, condenser chambers, Geiger Muller counter, Scintillation counters and Solid State detectors, ionization chamber, Dosimeters, survey methods, area monitors, TLD, Semiconductor detectors. (7 Lectures)

MEDICAL IMAGING PHYSICS: Evolution of Medical Imaging, X-ray diagnostics and imaging, Physics of nuclear magnetic resonance (NMR), NMR imaging, MRI Radiological imaging, Ultrasound imaging, Physics of Doppler with applications and modes, Vascular Doppler. Radiography: Filters, grids, cassette, X-ray film, film processing, fluoroscopy. **Computed tomography scanner**: principle & function, display, generations, mammography. Thyroid uptake system and Gamma camera (Only Principle, function and display). (9 Lectures)

RADIATION ONCOLOGY PHYSICS: External Beam Therapy (Basic Idea): Telecobalt, Conformal Radiation Therapy (CRT), 3DCRT, IMRT, Image Guided Radiotherapy, EPID, Rapid Arc, Proton Therapy, Gamma Knife, Cyber Knife. Contact Beam Therapy (Basic Idea): Brachytherapy-LDR and HDR, Intra Operative Brachytherapy. Radiotherapy, kilo voltage machines, deep therapy machines, Telecobalt machines, Medical linear accelerator. Basics of Teletherapy units, deep x-ray, Telecobalt units, medical linear accelerator, Radiation protection, external beam characteristics, dose maximum and build up – bolus, percentage depth dose, tissue maximum ratio and tissue phantom ratio, Planned target Volume and Gross Tumour Volume. (9 Lectures)


PHYSICS OF DIAGNOSTIC AND THERAPEUTIC SYSTEMS-II
Diagnostic nuclear medicine: Radiopharmaceuticals for radioisotope imaging,
Radioisotope imaging equipment, Single photon and positron emission tomography.

Therapeutic nuclear medicine: Interaction between radiation and matter Dose and isodose in radiation treatment.

Medical Instrumentation: Basic Ideas of Endoscope and Cautery, Sleep Apnea and Cpap Machines, Ventilator and its modes.  

(5 Lectures)

References:

- Medical Physics, J.R. Cameron and J.G. Skofronick, Wiley (1978)
- Christensen’s Physics of Diagnostic Radiology: Curry, Dowdey and Murry - Lippincot Williams and Wilkins (1990)
- Handbook of Physics in Diagnostic Imaging: R.S. Livingstone: B.I. Publication Pvt Ltd.
- The Physics of Radiology-H E Johns and Cunningham.

PRACTICALS -DSE LAB: Medical Physics

60 Lectures

1. Understanding the working of a manual Hg Blood Pressure monitor and measure the Blood Pressure.
2. Understanding the working of a manual optical eye-testing machine and to learn eye-testing.
3. Correction of Myopia (short sightedness) using a combination of lenses on an optical bench/breadboard.
4. Correction of Hypermetropia/Hyperopia (long sightedness) using a combination of lenses on an optical bench/breadboard.
5. To learn working of Thermoluminescent dosimeter (TLD) badges and measure the background radiation.
6. Familiarization with Geiger-Muller (GM) Counter and to measure background radiation.
7. Familiarization with Radiation meter and to measure background radiation.
8. Familiarization with the Use of a Vascular Doppler.

References:

- Christensen’s Physics of Diagnostic Radiology: Curry, Dowdey and Murry - Lippincot Williams and Wilkins (1990)
- The essential physics of Medical Imaging: Bushberg, Seibert, Leidholdt and
Skill Enhancement Course (any four) (Credit: 02 each)- SEC1 to SEC4

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. Use of Sextant to measure height of buildings, mountains, etc. (4 Lectures)


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

Reference Books:
• Performance and design of AC machines – M.G. Say, ELBS Edn.
COMPUTATIONAL PHYSICS
(Credits: 02)
Theory: 30 Lectures

The aim of this course is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.

- Highlights the use of computational methods to solve physical problems
- Use of computer language as a tool in solving physics problems (applications)
- Course will consist of hands on training on the Problem solving on Computers.

Introduction: Importance of computers in Physics, paradigm for solving physics problems for solution. Usage of linux as an Editor. Algorithms and Flowcharts: Algorithm: Definition, properties and development. Flowchart: Concept of flowchart, symbols, guidelines, types. Examples: Cartesian to Spherical Polar Coordinates, Roots of Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of sin (x) as a series, algorithm for plotting (1) lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal.  

(4 Lectures)


(5 Lectures)

Control Statements: Types of Logic (Sequential, Selection, Repetition), Branching Statements (Logical IF, Arithmetic IF, Block IF, Nested Block IF, SELECT CASE and ELSE IF Ladder statements), Looping Statements (DO-CONTINUE, DO-ENDDO, DO-WHILE, Implied and Nested DO Loops), Jumping Statements (Unconditional GOTO, Computed GOTO, Assigned GOTO) Subscripted Variables (Arrays: Types of Arrays, DIMENSION Statement, Reading and Writing Arrays), Functions and Subroutines (Arithmetic Statement Function, Function Subprogram and Subroutine), RETURN, CALL, COMMON and EQUIVALENCE Statements), Structure, Disk I/O Statements, open a file, writing in a file, reading from a file. Examples from physics problems.

Programming:
1. Exercises on syntax on usage of FORTRAN
2. Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write source codes in FORTRAN.
3. To print out all natural even/odd numbers between given limits.
4. To find maximum, minimum and range of a given set of numbers.
5. Calculating Euler number using \( \exp(x) \) series evaluated at \( x=1 \) \textbf{(6 Lectures)}

**Scientific word processing: Introduction to LaTeX:** TeX/LaTeX word processor, preparing a basic LaTeX file, Document classes, Preparing an input file for LaTeX, Compiling LaTeX File, LaTeX tags for creating different environments, Defining LaTeX commands and environments, Changing the type style, Symbols from other languages. \textbf{Equation representation:} Formulae and equations, Figures and other floating bodies, Lining in columns- Tabbing and tabular environment, Generating table of contents, bibliography and citation, Making an index and glossary, List making environments, Fonts, Picture environment and colors, errors. \textbf{(6 Lectures)}

**Visualization:** Introduction to graphical analysis and its limitations. Introduction to Gnuplot. Importance of visualization of computational and computational data, basic Gnuplot commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file, physics with Gnuplot (equations, building functions, user defined variables and functions), Understanding data with Gnuplot

**Hands on exercises:**
1. To compile a frequency distribution and evaluate mean, standard deviation etc.
2. To evaluate sum of finite series and the area under a curve.
3. To find the product of two matrices
4. To find a set of prime numbers and Fibonacci series.
5. To write program to open a file and generate data for plotting using Gnuplot.
6. Plotting trajectory of a projectile projected horizontally.
7. Plotting trajectory of a projectile projected making an angle with the horizontally.
8. Creating an input Gnuplot file for plotting a data and saving the output for seeing on the screen. Saving it as an eps file and as a pdf file.
9. To find the roots of a quadratic equation.
10. Motion of a projectile using simulation and plot the output for visualization.
11. Numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization.
12. Motion of particle in a central force field and plot the output for visualization. \textbf{(9 Lectures)}

**Reference Books:**
- Computer Programming in Fortran 77”, V. Rajaraman (Publisher:PHI).
- Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning 2010)
ELECTRICAL CIRCUITS AND NETWORK SKILLS
(Credits: 02)
Theory: 30 Lectures
The aim of this course is to enable the students to design and trouble shoots the electrical circuits, networks and appliances through hands-on mode


Generators and Transformers: DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers. (3 Lectures)

Electric Motors: Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heaters & motors. Speed & power of ac motor. (4 Lectures)

Solid-State Devices: Resistors, inductors and capacitors. Diode and rectifiers. Components in Series or in shunt. Response of inductors and capacitors with DC or AC sources (3 Lectures)


Reference Books:
• A text book in Electrical Technology - B L Theraja - S Chand & Co.
BASIC INSTRUMENTATION SKILLS
(Credits: 02)
Theory: 30 Lectures
This course is to get exposure with various aspects of instruments and their usage through hands-on mode. Experiments listed below are to be done in continuation of the topics.

Basic of Measurement: Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. Multimeter: Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance. (4 Lectures)


Cathode Ray Oscilloscope: Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time base operation, synchronization. Front panel controls. Specifications of a CRO and their significance. (6 Lectures)

Use of CRO for the measurement of voltage (dc and ac frequency, time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working. (3 Lectures)

Signal Generators and Analysis Instruments: Block diagram, explanation and specifications of low frequency signal generators. pulse generator, and function generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis. (4 Lectures)

Impedance Bridges & Q-Meters: Block diagram of bridge. working principles of basic (balancing type) RLC bridge. Specifications of RLC bridge. Block diagram & working principles of a Q-Meter. Digital LCR bridges. (3 Lectures)


Digital Multimeter: Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/frequency counter, time-base stability, accuracy and resolution. (3 Lectures)

The test of lab skills will be of the following test items:
1. Use of an oscilloscope.
2. CRO as a versatile measuring device.
3. Circuit tracing of Laboratory electronic equipment,
4. Use of Digital multimeter/VTVM for measuring voltages
5. Circuit tracing of Laboratory electronic equipment,
7. Study the layout of receiver circuit.
8. Trouble shooting a circuit
9. Balancing of bridges

**Laboratory Exercises:**
1. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
3. To measure Q of a coil and its dependence on frequency, using a Q-meter.
4. Measurement of voltage, frequency, time period and phase angle using CRO.
5. Measurement of time period, frequency, average period using universal counter/ frequency counter.
6. Measurement of rise, fall and delay times using a CRO.

**Open Ended Experiments:**
1. Using a Dual Trace Oscilloscope
2. Converting the range of a given measuring instrument (voltmeter, ammeter)

**Reference Books:**
- A text book in Electrical Technology - B L Theraja - S Chand and Co.
- Performance and design of AC machines - M G Say ELBS Edn.
- Electronic Devices and circuits, S. Salivahanan & N. S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
- Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

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**RENEWABLE ENERGY AND ENERGY HARVESTING**

(Credits: 02)

**Theory: 30 Lectures**

*The aim of this course is not just to impart theoretical knowledge to the students but to provide them with exposure and hands-on learning wherever possible*

**Fossil fuels and Alternate Sources of energy:** Fossil fuels and Nuclear Energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean
Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity.  

**Solar energy**: Solar energy, its importance, storage of solar energy, solar pond, non convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.  

**Wind Energy harvesting**: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies.  


**Hydro Energy**: Hydropower resources, hydropower technologies, environmental impact of hydro power sources.  

**Piezoelectric Energy harvesting**: Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications, Human power  

**Electromagnetic Energy Harvesting**: Linear generators, physics mathematical models, recent applications  

Carbon captured technologies, cell, batteries, power consumption  

Environmental issues and Renewable sources of energy, sustainability.  

**Demonstrations and Experiments**  
1. Demonstration of Training modules on Solar energy, wind energy, etc.  
2. Conversion of vibration to voltage using piezoelectric materials  
3. Conversion of thermal energy into voltage using thermoelectric modules.  

**Reference Books:**  
- Non-conventional energy sources - G.D Rai - Khanna Publishers, New Delhi  
- Solar energy - M P Agarwal - S Chand and Co. Ltd.  
- J.Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA).
TECHNICAL DRAWING  
(Credits: 02)  
Theory: 30 Lectures


(4 Lectures)

**Projections**: Straight lines, planes and solids. Development of surfaces of right and oblique solids. Section of solids.  

(6 Lectures)

**Object Projections**: Orthographic projection. Interpenetration and intersection of solids. Isometric and oblique parallel projection of solids.  

(4 Lectures)

**CAD Drawing**: Introduction to CAD and Auto CAD, precision drawing and drawing aids, Geometric shapes, Demonstrating CAD- specific skills (graphical user interface). Create, retrieve, edit, and use symbol libraries. Use inquiry commands to extract drawing data. Control entity properties. Demonstrating basic skills to produce 2-D and 3-D drawings. 3D modeling with Auto CAD (surfaces and solids), 3D modeling with sketch up, annotating in Auto CAD with text and hatching, layers, templates & design center, advanced plotting (layouts, viewports), office standards, dimensioning, internet and collaboration, Blocks, Drafting symbols, attributes, extracting data. basic printing, editing tools, Plot/Print drawing to appropriate scale.  

(16 Lectures)

**Reference Books**:
- K. Venugopal, and V. Raja Prabhu. Engineering Graphic, New Age International

Radiation Safety  
(Credits: 02)  
Theory: 30 Lectures

*The aim of this course is for awareness and understanding regarding radiation hazards and safety. The list of laboratory skills and experiments listed below the course are to be done in continuation of the topics*
Basics of Atomic and Nuclear Physics: Basic concept of atomic structure; X rays characteristic and production; concept of bremsstrahlung and auger electron, The composition of nucleus and its properties, mass number, isotopes of element, spin, binding energy, stable and unstable isotopes, law of radioactive decay, Mean life and half life, basic concept of alpha, beta and gamma decay, concept of cross section and kinematics of nuclear reactions, types of nuclear reaction, Fusion, fission. (6 Lectures)


Radiation detection and monitoring devices: Radiation Quantities and Units: Basic idea of different units of activity, KERMA, exposure, absorbed dose, equivalent dose, effective dose, collective equivalent dose, Annual Limit of Intake (ALI) and derived Air Concentration (DAC). Radiation detection: Basic concept and working principle of gas detectors (Ionization Chambers, Proportional Counter, Multi-Wire Proportional Counters (MWPC) and Gieger Muller Counter), Scintillation Detectors (Inorganic and Organic Scintillators), Solid States Detectors and Neutron Detectors, Thermo luminescent Dosimetry. (7 Lectures)


Application of nuclear techniques: Application in medical science (e.g., MRI, PET, Projection Imaging Gamma Camera, radiation therapy), Archaeology, Art, Crime detection, Mining and oil. Industrial Uses: Tracing, Gauging, Material Modification, Sterization, Food preservation. (5 Lectures)

Experiments:
1. Study the background radiation levels using Radiation meter
2. Study of characteristics of GM tube and determination of operating voltage and plateau length using background radiation as source (without commercial source).
3) Study of counting statistics using background radiation using GM counter.
4) Study of radiation in various materials (e.g. KSO4 etc.). Investigation of possible radiation in different routine materials by operating GM at operating voltage.
6) Detection of α particles using reference source & determining its half life using spark counter
7) Gamma spectrum of Gas Light mantle (Source of Thorium)

Reference Books:
2. G.F. Knoll, Radiation detection and measurements
3. Thermoluminescence Dosimetry, Mcknlay, A.F., Bristol, Adam Hilger (Medical Physics Handbook 5)
8. NCRP, ICRP, ICRU, IAEA, AERB Publications.

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APPLIED OPTICS
(Credits: 02)
THEORY: 30 Lectures

Theory includes only qualitative explanation. Minimum five experiments should be performed covering minimum three sections.

<table>
<thead>
<tr>
<th>(i) Sources and Detectors</th>
<th>(9 Periods)</th>
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Experiments on Lasers:

a. Determination of the grating radial spacing of the Compact Disc (CD) by reflection using He-Ne or solid state laser.
b. To find the width of the wire or width of the slit using diffraction pattern obtained by a He-Ne or solid state laser.
c. To find the polarization angle of laser light using polarizer and analyzer
d. Thermal expansion of quartz using laser

Experiments on Semiconductor Sources and Detectors:

a. V-I characteristics of LED
b. Study the characteristics of solid state laser
c. Study the characteristics of LDR
d. Photovoltaic Cell
e. Characteristics of IR sensor
**Fourier Optics**  
(6 Periods)

Concept of Spatial frequency filtering, Fourier transforming property of a thin lens

### Experiments on Fourier Optics:

#### a. Fourier optic and image processing
1. Optical image addition/subtraction
2. Optical image differentiation
3. Fourier optical filtering
4. Construction of an optical 4f system

#### b. Fourier Transform Spectroscopy

Fourier Transform Spectroscopy (FTS) is a powerful method for measuring emission and absorption spectra, with wide application in atmospheric remote sensing, NMR spectrometry and forensic science.

**Experiment:**

To study the interference pattern from a Michelson interferometer as a function of mirror separation in the interferometer. The resulting interferogram is the Fourier transform of the power spectrum of the source. Analysis of experimental interferograms allows one to determine the transmission characteristics of several interference filters. Computer simulation can also be done.

**Holography**  
(6 Periods)

Basic principle and theory: coherence, resolution, Types of holograms, white light reflection hologram, application of holography in microscopy, interferometry, and character recognition

### Experiments on Holography and interferometry:

1. Recording and reconstructing holograms
2. Constructing a Michelson interferometer or a Fabry Perot interferometer
3. Measuring the refractive index of air
4. Constructing a Sagnac interferometer
5. Constructing a Mach-Zehnder interferometer
6. White light Hologram

**Photonics: Fibre Optics**  
(9 Periods)

Optical fibres and their properties, Principal of light propagation through a fibre, The numerical aperture, Attenuation in optical fibre and attenuation limit, Single mode and multimode fibres, Fibre optic sensors: Fibre Bragg Grating

### Experiments on Photonics: Fibre Optics

a. To measure the numerical aperture of an optical fibre
b. To study the variation of the bending loss in a multimode fibre
c. To determine the mode field diameter (MFD) of fundamental mode in a single-mode fibre by measurements of its far field Gaussian pattern
d. To measure the near field intensity profile of a fibre and study its refractive index profile
e. To determine the power loss at a splice between two multimode fibre

### Reference Books:
WEATHER FORECASTING

(Credits: 02)

Theory: 30 Lectures

The aim of this course is not just to impart theoretical knowledge to the students but to enable them to develop an awareness and understanding regarding the causes and effects of different weather phenomenon and basic forecasting techniques.

Introduction to atmosphere: Elementary idea of atmosphere: physical structure and composition; compositional layering of the atmosphere; variation of pressure and temperature with height; air temperature; requirements to measure air temperature; temperature sensors: types; atmospheric pressure: its measurement; cyclones and anticyclones: its characteristics. (9 Periods)

Measuring the weather: Wind; forces acting to produce wind; wind speed direction: units, its direction; measuring wind speed and direction; humidity, clouds and rainfall, radiation: absorption, emission and scattering in atmosphere; radiation laws. (4 Periods)

Weather systems: Global wind systems; air masses and fronts: classifications; jet streams; local thunderstorms; tropical cyclones: classification; tornadoes; hurricanes. (3 Periods)

Climate and Climate Change: Climate: its classification; causes of climate change; global warming and its outcomes; air pollution; aerosols, ozone depletion, acid rain, environmental issues related to climate. (6 Periods)

Basics of weather forecasting: Weather forecasting: analysis and its historical background; need of measuring weather; types of weather forecasting; weather forecasting methods; criteria of choosing weather station; basics of choosing site and exposure; satellites observations in weather forecasting; weather maps; uncertainty and predictability; probability forecasts. (8 Periods)

Demonstrations and Experiments:
1. Study of synoptic charts & weather reports, working principle of weather station.
2. Processing and analysis of weather data:
(a) To calculate the sunniest time of the year.
(b) To study the variation of rainfall amount and intensity by wind direction.
(c) To observe the sunniest/driest day of the week.
(d) To examine the maximum and minimum temperature throughout the year.
(e) To evaluate the relative humidity of the day.
(f) To examine the rainfall amount month wise.


4. Formats and elements in different types of weather forecasts/ warning (both aviation and non aviation)

**Reference books:**

MATHEMATICS AND COMPUTER SCIENCE

Skill Enhancement Course (SEC)

SEC 1 (choose one)

1. Logic and Sets
2. Analytical Geometry
3. Number Theory

SEC 2 (choose one)

1. Vector Calculus
2. Transportation and Game Theory
3. Probability and Statistics

SEC 3 (choose one)

1. Computer Graphics
2. Electronic Commerce
3. Combinatorial Optimization

SEC 4 (choose one)

1. Modeling and Simulation
2. Graph Theory
3. Boolean Algebra

Discipline Specific Electives (DSE)

DSE 1B (choose one)

1. Matrices
2. Integral Calculus
3. Linear Algebra

DSE 2B (choose one)

1. Operating Systems
2. Data Mining
3. Cryptography
DSE 1C (choose one)

1. Difference Equations
2. Complex Analysis
3. Linear Programming

DSE 2C (choose one)

1. Information Security
2. Database Applications
3. Computer Networks

Core 1.1: Differential Calculus

Limit and Continuity (ε and δ definition), Types of discontinuities, Differentiability of functions, Successive differentiation, Leibnitz’s theorem, Partial differentiation, Euler’s theorem on homogeneous functions.


Rolle’s theorem, Mean Value theorems, Taylor’s theorem with Lagrange’s and Cauchy’s forms of remainder, Taylor’s series, Maclaurin’s series of sin x, cos x, e^x, log(1+x), (1+x)^m, Maxima and Minima, Indeterminate forms.

Books Recommended


Core 1.2: Object Oriented Programming in C++

Programming Concepts: Algorithm and its characteristics, pseudo code / flow chart, program, identifiers, variables, constants, primitive data types, expressions, structured data types, arrays, compilers and interpreters.

Statements: Assignment statement, if then else statements, switch statement, looping statements- while, do while, for, break, continue, input/output statements, functions/procedures. Object Oriented Concepts: Abstraction, encapsulation, objects, classes, methods, constructors, inheritance, polymorphism, static and dynamic
binding, overloading. Program Development: Object oriented analysis, design, unit testing & debugging, system testing & integration, maintenance.

Introduction to structured programming: data types- simple data types, floating data types, character data types, string data types, arithmetic operators and operator precedence, variables and constant declarations, expressions, input using the extraction operator >> and cin, output using the insertion operator << and cout, preprocessor directives, increment (++) and decrement operations (--), creating a C++ program, input/output, relational operators, logical operators and logical expressions, if and if … else statement, switch and break statements.

“for”, “while” and “do – while” loops, break and continue statement, nested control statement, value returning functions, void functions, value versus reference parameters, local and global variables, static and automatic variables, enumeration type, one dimensional array, two dimensional array, character array, pointer data and pointer variables.

Books Recommended

1. Richard Johnson, An Introduction to Object-Oriented Application Development, Thomson Learning, 2006


Core 2.1: Differential Equations


Classification of second order partial differential equations into elliptic, parabolic and hyperbolic through illustrations only.
Books Recommended


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Core 2.2: Data Structures and File Processing

Basic Data Structures: Abstract data structures- stacks, queues, linked lists and binary trees. Sets: Dictionary implementation, use of priority queues, hashing, binary trees, balanced trees, sets with merge-find operations.

Searching: Internal and external searching, use of hashing and balancing techniques.

Memory Management: Garbage collection algorithms for equal sized blocks, storage allocation for objects with mixed size, buddy systems.

Physical Devices: Characteristics of storage devices such as disks and tapes, I/O buffering. Basic File System Operations: Create, open, close, extend, delete, read-block, write-block, protection mechanisms.

File Organizations: Sequential, indexed sequential, direct, inverted, multi-list, directory systems, Indexing using B-tree, B+ tree and their variants, hashing – hash function, collision handling methods, extendible hashing.

Books Recommended


Core 3.1: Real Analysis

Finite and infinite sets, examples of countable and uncountable sets. Real line, bounded sets, suprema and infima, completeness property of R, Archimedean property of R, intervals. Concept of cluster points and statement of Bolzano-Weierstrass theorem.

Real Sequence, Bounded sequence, Cauchy convergence criterion for sequences. Cauchy’s theorem on limits, order preservation and squeeze theorem, monotone sequences and their convergence (monotone convergence theorem without proof).

Infinite series. Cauchy convergence criterion for series, positive term series, geometric series, comparison test, convergence of p-series, Root test, Ratio test, alternating series, Leibnitz’s test (Tests of Convergence without proof). Definition and examples of absolute and conditional convergence.

Sequences and series of functions, Pointwise and uniform convergence. Mₙ-test, M-test, Statements of the results about uniform convergence and integrability and differentiability of functions, Power series and radius of convergence.

Books Recommended


Core 3.2: Numerical Computing

method for solving systems of equations, Symmetric positive definite matrices and least square approximation, iterative algorithms for linear equations.

Interpolation: Polynomial interpolation, Newton-Gregory, Stirling’s, Bessel’s and Lagrange’s interpolation formula, Newton’s divided differences interpolation formulae. Curve fitting: B-spline and Approximation: Fitting linear and non-linear curves, weighted least square approximation, method of least square for continuous functions.


Books Recommended


Core 4.1: Algebra

Definition and examples of groups, examples of abelian and non-abelian groups, the group \( \mathbb{Z}_n \) of integers under addition modulo \( n \) and the group \( \mathbb{U}(n) \) of units under multiplication modulo \( n \). Cyclic groups from number systems, complex roots of unity,
circle group, the general linear group GL_n (n,R), groups of symmetries of (i) an isosceles triangle, (ii) an equilateral triangle, (iii) a rectangle, and (iv) a square, the permutation group Sym (n), Group of quaternions.

Subgroups, cyclic subgroups, the concept of a subgroup generated by a subset and the commutator subgroup of group, examples of subgroups including the center of a group. Cosets, Index of subgroup, Lagrange’s theorem, order of an element, Normal subgroups: their definition, examples, and characterizations, Quotient groups.

Definition and examples of rings, examples of commutative and non-commutative rings: rings from number systems, Z_n the ring of integers modulo n, ring of real quaternions, rings of matrices, polynomial rings, and rings of continuous functions. Subrings and ideals, Integral domains and fields, examples of fields: Z_p, Q, R, and C. Field of rational functions.

Books Recommended


Core 4.2: Design and Analysis of Algorithms


Searching and Sorting Techniques: Review of elementary sorting techniques-selection sort, bubble sort, insertion sort, more sorting techniques-quick sort, heap sort, merge sort, shell sort, external sorting.


Introduction to randomized algorithms: Random numbers, randomized Qsort, randomly Built BST Number Theoretic Algorithms: GCD, Addition and Multiplication of two large numbers, polynomial arithmetic, Fast-Fourier Transforms.
Graphs: Analysis of Graph algorithms Depth-First Search and its applications, minimum Spanning Trees and Shortest Paths. Introduction to Complexity Theory: Class P, NP, NP-Hard, NP Completeness. Introduction to Approximation Algorithms

Books Recommended


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SEC 1.1: Logic and Sets

Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators. Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations.


Difference and Symmetric difference of two sets. Set identities, Generalized union and intersections. Relation: Product set, Composition of relations, Types of relations, Partitions, Equivalence Relations with example of congruence modulo relation.

Book Recommended

SEC 1.2: Analytical Geometry


Books Recommended


SEC 1.3: Number Theory

Division algorithm, Lame’s theorem, linear Diophantine equation, fundamental theorem of arithmetic, prime counting function, statement of prime number theorem, Goldbach conjecture, binary and decimal representation of integers, linear congruences, complete set of residues.

Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Mobius inversion formula, the greatest integer function, Euler’s phi-function.
Books Recommended:


SEC 2.1: Vector Calculus


Books Recommended


SEC 2.2: Transportation and Game Theory

Transportation problem and its mathematical formulation, northwest-corner method, least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem, assignment problem and its mathematical formulation,
Hungarian method for solving assignment problem.

Game theory: formulation of two person zero sum games, solving two person zero sum games, games with mixed strategies, graphical solution procedure.

**Books Recommended**


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**SEC 2.3: Probability and Statistics**

Sample space, probability axioms, real random variables (discrete and continuous), cumulative distribution function, probability mass/density functions, mathematical expectation, moments, moment generating function, characteristic function, discrete distributions: uniform, binomial, Poisson, continuous distributions: uniform, normal, exponential.

Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions, expectation of function of two random variables, conditional expectations, independent random variables.

**Books Recommended**


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SEC 3.1: Computer Graphics

Development of computer Graphics: Raster Scan and Random Scan graphics storages, displays processors and character generators, colour display techniques, interactive input/output devices.

Points, lines and curves: Scan conversion, line-drawing algorithms, circle and ellipse generation, conic-section generation, polygon filling anti aliasing.

Two-dimensional viewing: Coordinate systems, linear transformations, line and polygon clipping algorithms.

Books Recommended


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SEC 3.2: Electronic Commerce

Building Blocks of Electronic Commerce: Introduction, internet and networking technologies, Internet and network protocols, web server scalability, software technologies for building E-commerce applications, distributed objects, object request brokers, component technology, web services, web application architectures.

Design of auction, optimization algorithms, for market places, multi-agent systems.

Global E-commerce and Law: Cyber law in India. Comparative evaluation of Cyber laws of certain countries.

Books Recommended


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**SEC 3.3: Combinatorial Optimization**

Introduction: Optimization problems, neighbourhoods, local and global optima, convex sets and functions, simplex method, degeneracy; duality and dual simplex algorithm, computational considerations for the simplex and dual simplex algorithms-Dantzig-Wolfe algorithms.

Integer Linear Programming: Cutting plane algorithms, branch and bound technique and approximation algorithms for travelling salesman problem.

**Books Recommended**


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**SEC 4.1: Modeling and Simulation**

Systems and environment: Concept of model and model building, model classification and representation, Use of simulation as a tool, steps in simulation study.

Continuous-time and Discrete-time systems: Laplace transform, transfer functions, state space models, order of systems, z-transform, feedback systems, stability, observability, controllability. Statistical Models in Simulation: Common discrete and continuous distributions, Poisson process, empirical distributions.

Random Numbers: Properties of random numbers, generation of pseudo random numbers, techniques of random number generation, tests for randomness, random variate generation using inverse transformation, direct transformation, convolution method, acceptance-rejection.

**Books Recommended**


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SEC 4.2: Graph Theory

Definition, examples and basic properties of graphs, pseudo graphs, complete graphs, bi-partite graphs, isomorphism of graphs, paths and circuits, Eulerian circuits, Hamiltonian cycles, the adjacency matrix, weighted graph, travelling salesman’s problem, shortest path, Dijkstra’s algorithm, Floyd-Warshall algorithm.

Books Recommended


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SEC 4.3: Boolean Algebra

Definition, examples and basic properties of ordered sets, maps between ordered sets, duality principle, maximal and minimal elements, lattices as ordered sets, complete lattices, lattices as algebraic structures, sublattices, products and homomorphisms.

Definition, examples and properties of modular and distributive lattices, Boolean algebras, Boolean polynomials, minimal forms of Boolean polynomials, Quinn-McCluskey method, Karnaugh diagrams, switching circuits and applications of switching circuits.

Books Recommended


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DSE 1B.1: Matrices

R, R², R³ as vector spaces over R. Standard basis for each of them. Concept of Linear Independence and examples of different bases. Subspaces of R², R³. Translation, Dilation, Rotation, Reflection in a point, line and plane.

Matrix form of basic geometric transformations. Interpretation of eigen values and eigenvectors for such transformations and eigen spaces as invariant subspaces. Matrices in diagonal form. Reduction to diagonal form upto matrices of order 3.


Books Recommended


DSE 1B.2: Integral Calculus

Integration by Partial fractions, integration of rational and irrational functions. Properties of definite integrals. Reduction formulae for integrals of rational, trigonometric, exponential and logarithmic functions and of their combinations.

Areas and lengths of curves in the plane, volumes and surfaces of solids of revolution. Double and Triple integrals.

Books Recommended


**DSE 1B.3: Linear Algebra**

Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces.

Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, algebra of linear transformations. Dual Space, Dual Basis, Double Dual, Eigen values and Eigen vectors, Characteristic Polynomial.

Isomorphisms, Isomorphism theorems, invertibility and isomorphisms, change of coordinate matrix.

**Books Recommended**


**DSE 2B.1: Operating Systems**

Books Recommended


DSE 2B.2: Data Mining

Overview: The process of knowledge discovery in databases, predictive and descriptive data mining techniques, supervised and unsupervised learning techniques. Techniques of Data Mining: Link analysis, predictive modeling, database segmentation, score functions for data mining algorithms, Bayesian techniques in data mining. Issues in Data Mining: Scalability and data management issues in data mining algorithms, parallel and distributed data mining, privacy, social, ethical issues in KDD and data mining, pitfalls of KDD and data mining.

Books Recommended


DSE 2B.3: Cryptography


Book Recommended


DSE 1C.1: Difference Equations


Linear Difference Equations: First Order Equations, General Results for Linear Equations, Solving Linear Equations, Applications, Equations with Variable Coefficients, Nonlinear Equations that can Be Linearized, The z-Transform.


Books Recommended


DSE 1C.2: Complex Analysis

Limits, Limits involving the point at infinity, continuity. Properties of complex numbers, regions in the complex plane, functions of complex variable, mappings. Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability.


Liouville’s theorem and the fundamental theorem of algebra. Convergence of sequences and series, Taylor series and its examples.

Laurent series and its examples, absolute and uniform convergence of power series.

Books Recommended


DSE 1C.3: Linear Programming

Linear Programming Problems, Graphical Approach for Solving some Linear Programs. Convex Sets, Supporting and Separating Hyperplanes.

Theory of simplex method, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two-phase method, Big-M method and their comparison.

Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual, sensitivity analysis.

Books Recommended


DSE 2C.1: Information Security


Books Recommended


DSE 2C.2: Database Applications

Application Design and Development: User interfaces and tools, web interfaces to Databases  Web Fundamentals: HTML, static vs. dynamic web pages, client (JavaScript/VB) and server side scripting (JSP/ASP/PHP/VB), web servers and sessions, two level & three level architecture, Real Life Application Development using Popular DBMS: SQL, procedures & functions, exception handling, triggers, large objects, user defined data types, collection types, bulk loading of data.

Query Optimization: Query Processing, query tree, query plans, measures of query cost, estimates of basic operations, equivalent relational algebra expressions, evaluation of expressions.

Authorizations in SQL: System and user privileges, granting and revoking privileges, roles, authorization on views, functions and procedures, limitations of SQL authorizations, audit trails Application Security: Encryption techniques, digital signatures and digital certificates.

Books Recommended


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**DSE 2C.3: Computer Networks**


Telephony: Multiplexing, error detection and correction, Many to one, one to many, WDM, TDM, FDM, circuit switching, packet switching and message switching. Data Link control protocols: Line discipline, flow control, error control, synchronous and asynchronous protocols overview. ISDN: Services, historical outline, subscriber’s access, ISDN, Layers, and broadband ISDN.

Devices: Repeaters, bridges, gateways, routers, The Network Layer, Design Issues, Network Layer Addressing and Routing concepts (Forwarding Function, Filtering Function);Routing Methods (Static and dynamic routing, Distributed routing, Hierarchical Routing);Distance Vector Protocol, Link State protocol.

Transport and upper layers in OSI Model: Transport layer functions, connection management, Functions of session layers, Presentation layer, and Application layer.

**Books Recommended**

