## Department of Integrated M.Sc. (Applied Mathematics)

| | | | | |
|---|---|---|---|---|
| 1. | MAN-001 | Mathematics-1 | BSC | 4 |
| 2. | PHN-001 | Mechanics | BSC | 4 |
| 3. | CEN-105 | Introduction to Environmental Studies | GSC | 3 |
| 4. | HS-001A | Communication Skills (Basic) | HSSC | 2 |
| 5. | HS-001B | Communication Skills (Advance) | HSSC | 2 |
| 6. | HSN-002 | Ethics and General Awareness | HSSC | 2 |
| 7. | MAN-101 | Introduction to Mathematical Sciences | DCC | 2 |
| 8. | MAN-103 | Introduction to Computer Programming | ESC | 4 |
| 9. | MAN-004 | Numerical Methods | BSC | 4 |
| 10. | PHN-008 | Electromagnetic Theory | BSC | 4 |
| 11. | MAN-102 | Linear Algebra | DCC | 4 |
| 12. | MAN-104 | Real Analysis I | DCC | 4 |
| 13. | MAN-106 | Data Structures | DCC | 4 |
| 14. | ECN-102 | Fundamental of Electronics | ESC | 4 |
| 15. | CEN-102 | Solid Mechanics | ESC | 4 |
| 16. | MAN-201 | Complex Analysis I | DCC | 4 |
| 17. | MAN-203 | Discrete Mathematics | DCC | 4 |
| 18. | MAN-205 | Ordinary and Partial Differential Equations | DCC | 4 |
| 19. | MAN-291 | Design and Analysis of Algorithms | DCC | 3 |
| 20. | CEN-142 | Fluid Mechanics | ESC | 4 |
| 21. | MAN-202 | Transform Techniques | DCC | 4 |
| 22. | MAN-204 | Database Management System | DCC | 4 |
| 23. | MAN-206 | Graph Theory | DCC | 4 |
| 24. | MAN-208 | Number Theory | DCC | 4 |

| | | | | |
|---|---|---|---|---|
| 25. | MAN-301 | Abstract Algebra I | DCC | 4 |
| 26. | MAN-303 | Mathematical Statistics | DCC | 4 |
| 27. | MAN-305 | Linear Programming | DCC | 4 |
| 28. | MAN-302 | Math. Modeling & Simulation | DCC | 4 |
| 29. | MAN-304 | Theory of Computation | DCC | 4 |
| 30. | MAN-501 | Theory of Ordinary Differential Equations | DCC | 3 |
| 31. | MAN-503 | Real Analysis II | DCC | 3 |
| 32. | MAN-505 | Topology | DCC | 3 |
| 33. | MAN-507 | Statistical Inference | DCC | 3 |
| 34. | MAN-502 | Advanced Numerical Analysis | DCC | 4 |
| 35. | MAN-504 | Abstract Algebra II | DCC | 3 |
| 36. | MAN-506 | Nonlinear Programming | DCC | 4 |
| 37. | MAN-508 | Theory of Partial Differential Equations | DCC | 3 |
| 38. | MAN-510 | Complex Analysis II | DCC | 3 |
| 39. | MAN-601 | Fluid Dynamics | DCC | 3 |
| 40. | MAN-603 | Tensors and Differential Geometry | DCC | 3 |
| 41. | MAN-605 | Functional Analysis | DCC | 3 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **Department of Civil Engineering**

1. Subject code: **CEN-102** Course Title: **Solid Mechanics**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs): **Theory: 3** **Practical: 0**
4. Relative Weightage: **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **ESC**
8. Pre-requisite: **Nil**
9. Objective : To introduce the concepts of equilibrium and deformation in components, and structures for engineering design.
10. Details of Course :

| S. No. | Contents | Contact Hours |
|---|---|---|
| 1. | **Analysis of Stresses and Strains :** Concept of stress, normal stress and shear stress, nine Cartesian components of stress at a point, sign convention and notation, equality of shear stresses on mutually perpendicular planes and their planes of action, stress circle; Concept of strain, normal and shear strain, two dimensional state of strain, Poisson's ratio, volumetric strain, strain circle, Concept of strain energy | **08** |
| 2. | **Stress-Strain Relationships :** Hooke's law and its application to isotropic materials, elastic constants and their relationships, plane stress and plain strain conditions. | **02** |
| 3. | **Mechanical Properties :** Uniaxial tension test to determine yield and ultimate strength of materials, stress-strain diagram, proof stress, ductile and brittle materials, hardness and impact strength; Conditions affecting mechanical behaviour of engineering materials | **02** |
| 4. | **Members in Uniaxial State of Stress :** Uniform cross-section and tapered bars subjected to uniaxial tension and compression, composite bars and statically indeterminate bars, thermal stresses; Introduction to plasticity; S.E. under axial loading. | **04** |
| 5. | **Members Subjected to Axi-Symmetric Loads :** Stresses and strains in thin cylindrical shells and spheres under internal pressure, stresses in thin rotating rings. | **02** |
| 6. | **Members Subjected to Torsional Loads :** Torsion of solid and hollow circular shafts, stepped and composting shafts, close-coiled helical springs subjected to axial loads, S.E. in | **02** |

| | | |
|---|---|---|
| | torsion. | |
| 7. | **Members S ubjected t o Flexural L oads :** Statically determinate beams, support reactions, relationship between load, shear force and bending moment, shear force and bending moment diagrams; Theory of flexure for initially straight beams, distribution of bending stresses across the beam cross-section, principal stresses in beams; Equation of elastic curve for the loaded beam, relationship between bending moment, slope and deflection; Calculation of deflection by integration, moment area and unit-load methods, S.E. in flexure. | **15** |
| 8. | **Members Subj ected t o Combined L oads :** Short struts subjected to eccentric loads, shafts subjected to combined bending, torsion and axial thrust, concept of theory of failure. | **02** |
| 9. | **Elastic S tability of C olumns :** Euler's theory of initially straight columns, critical loads for different end condition of columns, eccentric loading, columns with small initial curvature, empirical formulae. | **02** |
| 10. | **Stresses i n B eams (Advance T opics) :** Composite beams, Transformed section method, Bending of unsymmetric beams, The shear-center concept. | **03** |
| | **TOTAL** | **42** |

11. Suggested Books :

| S. No. | Name of Authors / Books / Publishers | Year of Publication/ Reprint |
|---|---|---|
| 1. | Gere, J.M. and Goodno, B.J., "Strength of Materials", Indian Edition (4th reprint), Cengage Learning India Private Ltd. | 2009 |
| 2. | Beer, F.P., Johuston, Jr., E.R., Dewolf, J.T. and Mazureu, D.E., "Mechanics of Materials", Fifth Edition, McGraw Hill. | 2009 |
| 3. | Hibbeler, R.C., "Mechanics of Materials", Sixth Edition, Pearson. | 2005 |
| 4. | Crandall, S.H., Dahl, N.C. and Lardner, T.J., "An Introduction to the Mechanics of Solids", 2nd Edition, McGraw Hill. | 1999 |
| 5. | Timoshenko, S.P. and Young, D.H., "Elements of Strength of Materials", Fifth Edition, (In MKS Units), East-West Press Pvt. Ltd. | 2009 (reprint) |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electronics and Communication Engineering**

1. Subject Code: **ECN-102** Course Title: **Fundamentals of Electronics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weightage**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: ESC**

8. Pre-requisite**: Nil**

9. Objective: To impart knowledge of basic principles of electronics to UG students from other disciplines of engineering and science.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Review of properties of metals, dielectrics and semiconductors. | **1** |
| **2.** | **Diodes**: Working principle and characteristics and diode applications (rectification with capacitive filter and zener regulation). | **4** |
| **3.** | **BJT**: Operation and characteristics, brief overview of DC biasing, 're' model, Amplifier (CE, CB and CC). | **6** |
| **4.** | **MOSFET**: Introduction to MOSFET operation and characteristics. | **1** |
| **5.** | **Operational Amplifiers**: Input modes and parameters, introduction to concept of negative feedback, negative feedback in OPAMP, bias currents and offsets, open and closed loop responses. | **5** |
| **6.** | **Op-Amp A pplications**: Comparator, summing, integrator, differentiator, instrumentation amplifiers, isolation amplifiers, Operational Transconductance Amplifiers, Log and Antilog amplifiers, Converters, Introduction to OPAMP based active filters, Brief description of OPAMP based oscillators. | **8** |
| **7.** | **Basic D igital E lectronics**: Binary number system, Boolean algebra, Logic gates, adders, one-bit memory, flip-flops (SR, JK), shift registers, Asynchronous counter. | **8** |
| **8.** | **Introduction t o microprocessor**: Four-bit microprocessor architecture, stored program computer, instruction set and basic assembly language programming. | **9** |
| | **Total** | **42** |

11. Suggested Books:

| S.No. | Name of Authors / Books / Publishers | Year of Publication/ Reprint |
|---|---|---|
| 1. | Boylstead R.L., Nashelsky L., "Electronic Devices and Circuit Theory", Pearson, 10th Edition. | 2009 |
| 2. | Floyd T.L., Buchla D.L., "Electronics Fundamentals: Circuits, Devices and Applications", 8th Edition | 2010 |
| 3. | Millman J., Halkias C.C., Jit S., "Electronic Devices and Circuits", Tata McGraw-Hill, 2nd Edition. | 2007 |
| 4. | Dorf R.C., Smith R.J., "Circuits, Devices and Systems: A First Course in Electrical Engineering", 5th Edition | 1991 |

| | | | | |
|---|---|---|---|---|
| **Department Elective Courses (MA Elective-I and MA Elective-II) to be chosen in Third Year** | | | | |
| 1. | MA-321 | Biomathematics | DEC | 3 |
| 2. | MA-322 | Combinatorial Mathematics | DEC | 3 |
| 3. | MA-323 | Computer Graphics | DEC | 3 |
| 4. | MA-324 | Fuzzy Sets and Fuzzy Logic | DEC | 3 |
| 5. | MA-325 | Mathematical Imaging Techniques | DEC | 3 |
| 6. | MA-326 | Numerical Optimization | DEC | 3 |
| **Department Elective Courses (MA Elective-III and MA Elective-IV) to be chosen in Fourth Year** | | | | |
| 1. | MA-521 | Advanced Graph Theory | DEC | 3 |
| 2. | MA-522 | Computer Vision | DEC | 3 |
| 3. | MA-523 | Control Theory | DEC | 3 |
| 4. | MA-524 | Integral Equations and Calculus of Variations | DEC | 3 |
| 5. | MA-525 | Robotics and Control | DEC | 3 |
| 6. | MA-526 | Soft Computing | DEC | 3 |
| 7. | MA-527 | Stochastic Process | DEC | 3 |
| **Department Elective Courses (MA Elective-V, MA Elective-VI and MA Elective-VII) to be chosen in Fifth Year** | | | | |
| 1. | MA-621 | Abstract Harmonic Analysis | DEC | 3 |
| 2. | MA-622 | Algebraic Number Theory | DEC | 3 |
| 3. | MA-623 | Algebraic Topology | DEC | 3 |
| 4. | MA-624 | Approximation Theory | DEC | 3 |
| 5. | MA-625 | Coding Theory | DEC | 3 |
| 6. | MA-626 | Commutative Algebra | DEC | 3 |
| 7. | MA-627 | Dynamical Systems | DEC | 3 |
| 8. | MA-628 | Evolutionary Algorithms | DEC | 3 |
| 9. | MA-629 | Financial Mathematics | DEC | 3 |
| 10. | MA-630 | Finite Element Methods | DEC | 3 |
| 11. | MA-631 | Multivariate Techniques | DEC | 3 |
| 12. | MA-632 | Optimal Control Theory | DEC | 3 |
| 13. | MA-633 | Orthogonal Polynomials and Special Functions | DEC | 3 |
| 14. | MA-634 | Parallel Computing | DEC | 3 |
| 15. | MA-635 | Wavelet Theory | DEC | 3 |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Mathematics**

1. Subject Code: **MA-321** Course Title: **Biomathematics**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weightage**:** **CWS** **15** **PRS** **0** **MTE** **35** **ETE** **50** **PRE** **0**

5. Credits**:** **3** 6. Semester**: Autumn/Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** Nil

9. Objective: To provide a rapid introduction to the mathematical and computational topics appropriate for understanding biological processes.

10. Details of Course:

| **S. No.** | Contents | Contact Hours |
|---|---|---|
| **1.** | Mathematical Biology and the modeling process: an overview. | **02** |
| **2.** | Continuous models: Malthus model, logistic growth, Allee effect, Gompertz growth, Michaelis-Menten Kinetics, Holling type growth, Bacterial growth in a Chemostat, Harvesting a single natural population, Prey predator systems and Lotka Volterra equations, Populations in competitions, Epidemic Models (SI, SIR, SIRS, SIC), Activator-Inhibitor system, Insect Outbreak Model: Spruce Budworm, Numerical solution of the models and its graphical representation. | **08** |
| **3.** | Qualitative analysis of continuous models: Steady state solutions, stability and linearization, multiple species communities and Routh-Hurwitz Criteria, Phase plane methods and qualitative solutions, bifurcations and limit cycles with examples in the context of biological scenario. | **10** |
| **4.** | Spatial Models: One species model with diffusion, Two species model with diffusion, Conditions for diffusive instability, Spreading colonies of microorganisms, Blood flow in circulatory system, Traveling wave solutions, Spread of genes in a population. | **08** |
| **5.** | Discrete Models: Overview of difference equations, steady state solution and | **10** |

| | | |
|---|---|---|
| | linear stability analysis, Introduction to Discrete Models, Linear Models, Growth models, Decay models, Drug Delivery Problem, Discrete Prey-Predator models, Density dependent growth models with harvesting, Host-Parasitoid systems (Nicholson-Bailey model), Numerical solution of the models and its graphical representation. | |
| **6.** | Case Studies: Optimal Exploitation models, Models in Genetics, Stage Structure Models, Age Structure Models. | **04** |
| | **Total** | **42** |

11. Suggested Books:

| **S. No.** | **Name of the Authors / Books / Publisher** | **Year of Publication** |
|---|---|---|
| **1.** | Keshet, L. E., "Mathematical Models in Biology", SIAM | **1988** |
| **2.** | Murray, J. D., "Mathematical Biology", Springer | **1993** |
| **3.** | Fung, Y. C., "Biomechanics", Springer-Verlag | **1990** |
| **4.** | Brauer, F., Driessche, P. V. D. and Wu, J., "Mathematical Epidemiology", Springer | **2008** |
| **5** | Kot, M., "Elements of Mathematical Ecology", Cambridge University Press | **2001** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTR: **MATHEMATICS**

1. Subject Code: **MA-322** Course Title: **Combinatorial Mathematics**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weightage**:** **CWS** **15** **PRS** **0** **MTE** **35** **ETE** **50** **PRE** **0**

5. Credits**:** **3** 6. Semester**: Autumn/Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** Basic knowledge of Group theory

9. Objective: To introduce some basic concepts and techniques in combinatorics such as basic counting methods, generating functions, recurrence relations, Polya's counting theory and combinatorial designs.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Basic counting principles, Permutations and Combinations (with and without repetitions), Binomial theorem, Multinomial theorem, Counting subsets, Set-partitions, Stirling numbers | **5** |
| **2.** | Principle of Inclusion and Exclusion, Derangements, Inversion formulae | **4** |
| **3.** | Generating functions: Algebra of formal power series, Generating function models, Calculating generating functions, Exponential generating functions. Recurrence relations: Recurrence relation models, Divide and conquer relations, Solution of recurrence relations, Solutions by generating functions. | **9** |
| **4.** | Integer partitions, Systems of distinct representatives. | **6** |
| **5.** | Polya theory of counting: Necklace problem and Burnside's lemma, Cyclic index of a permutation group, Polya's theorems and their immediate applications. | **7** |
| **6.** | Latin squares, Hadamard matrices, Combinatorial designs: *t*-designs, BIBDs, Symmetric designs. | **11** |
| | **Total** | **42** |

11. Suggested Books:

| S. No. | Title/Authors/Publishers | Year of Publication |
|---|---|---|
| **1.** | Lint, J. H. van, and Wilson, R. M.: "*A Course in Combinatorics*", Cambridge University Press (2nd Ed.) | **2001** |
| **2.** | Krishnamurthy, V.: "*Combinatorics: Theory and Applications*", Affiliated East-West Press | **1985** |
| **3.** | Cameron, P. J.: "*Combinatorics: Topics, Techniques, Algorithms*", Cambridge University Press | **1995** |
| **4.** | Hall, M. Jr.: "*Combinatorial Theory*", John Wiley & Sons (2nd Ed.) | **1986** |
| **5.** | Sane, S. S.: "*Combinatorial Techniques*", Hindustan Book Agency | **2013** |
| **6.** | Brualdi, R. A.: "*Introductory Combinatorics*", Pearson Education Inc. (5th Ed.) | **2009** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **MATHEMATICS**

1. Subject Code: **MA-323** Course Title: **Computer Graphics**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weightage**:** **CWS** **15** **PRS** **0** **MTE** **35** **ETE** **50** **PRE** **0**

5. Credits**:** **3** 6. Semester**: Autumn/Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **Nil**

9. Objective: This course is designed to provide a comprehensive introduction to various topics of computer graphics.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| 1. | **Introduction:** Basic concepts in Computer Graphics, Graphics' hardware, input and output devices with their functionalities | 5 |
| 2. | **Line and Curve Drawing Algorithms:** Scan conversion and pixel plotting, parametric representation, Incremental line drawing, DDA and Bresenham's algorithms for drawing straight line and circle, Polygon and pattern filling | 7 |
| 3. | **2-D and 3-D Transformations:** Window-to-viewport mapping, Geometrical objects and transformations in 2D and 3D, homogeneous coordinates, matrix representation, viewing, Parallel and perspective projections, Different clipping algorithms | 8 |
| 4. | **Curves and Surfaces:** Parametric representations of curves and surfaces, Splines, Bezier curve, B-spline, Introduction to NURBS curves and surfaces | 10 |
| 5. | **3-D Object Modeling:** Polygon and meshes, Hidden surface removal: object-space and image-space methods, Solid modeling: sweep representation, boundary representation | 6 |
| 6. | **Shading and Illumination:** Light, shading and materials, Illumination and shading models, light sources, ray tracing | 3 |

| | | |
|---|---|---|
| **7.** | **Fractals :** Introduction to fractals with their developments and applications | **3** |
| | **Total** | **42** |

11. Suggested Books:

| S. No. | Name of Authors/Book/Publishers | Year of Publication/ Reprint |
|---|---|---|
| **1.** | Foley, D. J., Dam, A. V., Feiner, S. K. and Hughes, J. F., "Computer Graphics : Principles & Practices", Pearson Education, 2nd Ed. | **2007** |
| **2.** | Donald H. and Baker, M. P., "Computer Graphics", Pearson Education, 2nd Ed. | **2004** |
| **3.** | Rogers, D. F. and Adams, J. A., "Mathematical Elements of Computer Graphics", Tata McGraw-Hill, 2nd Ed. | **2008** |
| **4.** | Shirley, P., Ashikhmin, M. and Marschner, S., "Fundamentals of Computer Graphics", A K Peters/CRC Press, 3rd Ed. | **2009** |
| **5.** | Angel, E., "Interactive Computer Graphics", Addison-Wesley, 6th Ed. | **2012** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Mathematics**

1. Subject Code: **MA-324** Course Title:**Fuzzy Sets and Fuzzy Logics**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weightage**:** **CWS** **15** **PRS** **0** **MTE** **35** **ETE** **50** **PRE** **0**

5. Credits**:** **3** 6. Semester**: Autumn/Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** Nil

9. Objective: To introduce the basic concepts of Fuzzy sets and Fuzzy logics.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| 1 | **Fuzzy Sets and Uncertainty:** Uncertainty and information, fuzzy sets and membership functions, chance verses fuzziness, properties of fuzzy sets, fuzzy set operations. | 5 |
| 2 | **Fuzzy Relations:** Cardinality, operations, properties, fuzzy cartesian product and composition, fuzzy tolerance and equivalence relations, forms of composition operation. | 5 |
| 3 | **Fuzzification and Defuzzification:** Various forms of membership functions, fuzzification, defuzzification to crisp sets and scalars. | 5 |
| 4 | **Fuzzy Logic and Fuzzy Systems:** Classic and fuzzy logic, approximate reasoning, Natural language, linguistic hedges, fuzzy rule based systems, graphical technique of inference. | 7 |
| 5 | **Development of membership functions:** Membership value assignments: intuition, inference, rank ordering, neural networks, genetic algorithms, inductive reasoning. | 5 |
| 6 | **Fuzzy Arithmetic and Extension Principle:** Functions of fuzzy sets, | 5 |

| | | |
|---|---|---|
| | extension principle, fuzzy mapping, interval analysis, vertex method and DSW algorithm. | |
| 7 | **Fuzzy O ptimization:** One dimensional fuzzy optimization, fuzzy concept variables and casual relations, fuzzy cognitive maps, agent based models. | 5 |
| 8 | **Fuzzy C ontrol S ystems:** Fuzzy control system design problem, fuzzy engineering process control, fuzzy statistical process control, industrial applications. | 5 |
| | **Total** | **42** |

11. Suggested Books:

| **S. No.** | **Name of Books/ Authors/ Publishers** | **Year of publication** |
|---|---|---|
| **1** | Ross, T. J., "Fuzzy Logic with Engineering Applications", Wiley India Pvt. Ltd., 3rd Ed. | **2011** |
| **2** | Zimmerman, H. J., "Fuzzy Set theory and its application", Springer India Pvt. Ltd., 4th Ed. | **2006** |
| **3** | Klir, G. and Yuan, B., "Fuzzy Set and Fuzzy Logic: Theory and Applications", Prentice Hall of India Pvt. Ltd. | **2002** |
| **4** | Klir, G. and Folger, T., "Fuzzy Sets, Uncertainty and Information", Prentice Hall of India Pvt. Ltd. | **2002** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **MATHEMATICS**

1. Subject Code: **MA-325** Course Title: **Mathematical Imaging Techniques**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weightage**:** **CWS** **15** **PRS** **0** **MTE** **35** **ETE** **50** **PRE** **0**

5. Credits**:** **3** 6. Semester**: Autumn/Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **Nil**

**9. O bjective:** To introduce the fundamentals of image processing and various mathematical techniques used in image analysis.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| 1. | **Image f undamentals:** A simple image formation model, sampling and quantization, connectivity and adjacency relationships between pixels | 3 |
| 2. | **Spatial d omain filtering:** Basic intensity transformations: negative, log, power-law and piecewise linear transformations, bit-plane slicing, histogram equalization and matching, smoothing and sharpening filtering in spatial domain, unsharp masking and high-boost filtering | 7 |
| 3. | **Frequency domain filtering:** Fourier Series and Fourier transform, discrete and fast Fourier transform, sampling theorem, aliasing, filtering in frequency domain, lowpass and highpass filters, bandreject and bandpass filters, notch filters | 8 |
| 4. | **Image r estoration:** Introduction to various noise models, restoration in presence of noise only, periodic noise reduction, linear and position invariant degradation, estimation of degradation function | 6 |
| 5. | **Image re construction:** Principles of computed tomography, projections and Radon transform, the Fourier slice theorem, reconstruction using parallel-beam and fan-beam by filtered backprojection methods | 6 |

| | | |
|---|---|---|
| **6.** | **Mathematical morphology:** Erosion and dilation, opening and closing, the Hit-or-Miss transformation, various morphological algorithms for binary images | **6** |
| **7.** | **Wavelets and multiresolution processing:** Image pyramids, subband coding, multiresolution expansions, the Haar transform, wavelet transform in one and two dimensions, discrete wavelet transform | **6** |
| | **Total** | **42** |

11. Suggested Books:

| S. No. | Title/Authors/Publishers | Year of Publication/ Reprint |
|---|---|---|
| **1.** | Gonzalez, R. C. and Woods, R. E., "Digital Image Processing", Prentice Hall, 3rd Ed. | **2009** |
| **2.** | Jain, A. K., "Fundamentals of Digital Image Processing", PHI Learning, 1st Ed. | **2011** |
| **3.** | Bernd, J., "Digital Image Processing", Springer, 6th Ed. | **2005** |
| **4.** | Burger, W. and Burge, M. J., "Principles of Digital Image Processing", Springer | **2009** |
| **5.** | Scherzer, O., " Handbook of Mathematical Methods in Imaging", Springer | **2011** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Mathematics**

1. Subject Code: **MA-326** Course Title: **Numerical Optimization**

2. Contact Hours: L: 3 T: 0 P: 0

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **15** PRS **0** MTE **35** ETE **50** PRE **0**

5. Credits: **3** 6. Semester: Both 7. Subject Area: DEC

8. Pre-requisite: Nil

9. Objective: To acquaint the students with the basic concepts of Numerical Optimization

10. Details of Course:

| S.No. | Contents | Contact Hours |
|---|---|---|
| **1.** | **Linear Programming:** Review of various methods of linear programming | **5** |
| **2.** | Nonlinear Programming 1-D Unconstrained Minimization Methods: Golden Section, Fibonnacci Search, Bisection, Newton's Methods. | **6** |
| **3.** | **Multi-dimensional Unconstrained Minimization Methods:** Cyclic Co-ordinate Method, Hookes & Jeeves continuous and discrete methods, Rosenbrock method, Nelder & Mead method, Box's Complex method, Powell method, Steepest descent method, Newton's method, conjugate gradient method. | **10** |
| **4.** | **Constrained Minimization:** Rosen's gradient projection method for linear constraints, Zoutendijk method of feasible directions for nonlinear constraints, generalized reduced gradient method for nonlinear constraints. | **6** |
| **5.** | **Penalty function methods:** Exterior point penalty, Interior point penalty. | **4** |
| **6.** | Computer Programs of above methods. Case studies from Engineering and Industry, Use of software packages such as LINDO, LINGO, EXCEL, TORA, MATLAB | **11** |
| | Total | **42** |

11. Suggested Books

| S. No. | Title/Authors/Publishers | Year of Publication |
|---|---|---|
| **1.** | Bazaraa, M. S., Sherali, H. D. and Shetty, C. M.:"Nonlinear Programming Theory and Algorithms", 2nd Edition, John Wiley and Sons. | **1993** |
| **2.** | Belegundu, A. D. and Chandrupatla, T. R. :"Optimization Concepts and Applications in Engineering", Pearson Education Pvt. Ltd. | **2002** |
| **3.** | Deb, K.: "Optimization for Engineering Design Algorithms and Examples", Prentice Hall of India. | **1998** |
| **4.** | Mohan, C. and Deep, K.: "Optimization Techniques", New Age India Pvt. Ltd. | **2009** |
| **5.** | Nocedal, J. and Wright, S. J.: "Numerical Optimization", Springer Series in Operations Research, Springer-Verlag. | **2000** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Mathematics**

1. Subject Code: **MA-521** Course Title: **Advanced Graph Theory**

2. Contact Hours: L: 3 T: 0 P: 0

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **15** PRS **0** MTE **35** ETE **50** PRE **0**

5. Credits: **3** 6. Semester: Both 7. Subject Area: DEC

8. Pre-requisite: Nil

9. Objective: To introduce some advanced topics and concepts of graph theory.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Review of basic definitions and concepts of graph theory | **4** |
| **2.** | Matchings and Factors: Maximum matchings, Hall's matching condition, min-max theorems, independent sets and covers, dominating sets, algorithms for maximum bipartite, weighted bipartite and stable matchings and their applications, matchings in general graphs, Tutte's 1- factor theorem, Berge-Tutte formula, Petersen's results regarding regular graphs and factors. | **12** |
| **3.** | Stable Sets and Cliques: Stable sets, stability and clique numbers, Shannon capacity, stable sets in digraphs, kernels Turan's theorem and its application to combinatorial geometry, Ramsey's theorem, Ramsey numbers and Ramsey graphs, bounds on Ramsey numbers, application of Ramsey's theorem to number theory, the regularity lemma, regular pairs and regular partitions, the Erdos- Stone theorem, linear Ramsey numbers. | **12** |
| **4.** | Perfect Graphs:The perfect graph theorem,chordal graphs and other classes of perfect graphs, imperfect graphs, the strong perfect graph conjecture. | **6** |
| **5.** | Matroids: Hereditary systems, properties of matroids, the span function, dual of a matroid, matroid minors and planar graphs, matroid intersection,union. | **4** |
| **6.** | Eigen values of Graphs: Characteristic polynomial, eigenvalues and graph | **4** |

| | | |
|---|---|---|
| | parameters, eigen values of regular graphs, eigenvalues and expanders, strongly regular graphs. | |
| | Total | 42 |

11. Suggested Books:

| S. No. | Title/Authors/Publishers | Year of Publication |
|---|---|---|
| **1** | West, D. B."Introduction to Graph Theory",2nd Ed.Pearson Education | **2012** |
| **2** | Bondy, J.A.and Murty, U. S. R.,"Graph theory", Springer | **2011** |
| **3** | Diestel, R.,"Graph Theory" 4th Ed.,Spriger | **2010** |
| **4** | Chartrand, G. and Zhang, P.,"Introduction to Graph Theory",Tata McGraw Hill | **2007** |
| **5** | Bela, B., "Modern Graph Theory" Springer | **2005** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **MATHEMATICS**

1. Subject Code: **MA-522** Course Title: **Computer Vision**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weightage**:** **CWS** **15** **PRS** **0** **MTE** **35** **ETE** **50** **PRE** **0**

5. Credits**:** **3** 6. Semester**: Autumn/Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **Nil**

**9. Objective:** To introduce various topics of computer vision with their applications.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **4.** | **Image formation and camera calibration:** Introduction to computer vision, geometric camera models, orthographic and perspective projections, weak-perspective projection, intrinsic and extrinsic camera parameters, linear and nonlinear approaches of camera calibration | **8** |
| **5.** | **Feature de tection an d matching:** Edge detection, interest points and corners, local image features, feature matching and Hough transform, model fitting and RANSAC, scale invariant feature matching | **6** |
| **6.** | **Stereo Vision:** Stereo camera geometry and epipolar constraints, essential and fundamental matrix, image rectification, local methods for stereo matching: correlation and multi-scale approaches, global methods for stereo matching: order constraints and dynamic programming, smoothness and graph based energy minimization, optical flow | **12** |
| **7.** | **Shape from Shading:** Modeling pixel brightness, reflection at surfaces, the Lambertian and specular model, area sources, photometric stereo: shape from multiple shaded images, modeling inter-reflection, shape from one shaded image | **10** |
| **8.** | **Structure f rom motion:** Camera self-calibration, Euclidean structure and motion from two images, Euclidean structure and motion from multiple images, structure and motion from weak-perspective and multiple cameras | **6** |
| | **Total** | **42** |

11. Suggested Books:

| S. No. | Title/Authors/Publishers | Year of Publication/ Reprint |
|---|---|---|
| **1.** | Forsyth, D. A. and Ponce, J., "Computer Vision: A Modern Approach", Prentice Hall, 2nd Ed. | **2011** |
| **2.** | Szeliki, R., "Computer Vision: Algorithms and Applications", Springer | **2011** |
| **3.** | Hartley, R. and Zisserman, A., "Multiple View Geometry in Computer Vision", Cambridge University Press | **2003** |
| **4.** | Gonzalez, R. C. and Woods, R. E., "Digital Image Processing", Prentice Hall, 3rd Ed. | **2009** |
| **5.** | Trucco, E. and Verri, A., "Introductory Techniques for 3-D Computer Vision", Prentice Hall | **1998** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Mathematics**

1. Subject Code: **MA-523** Course Title:**Control Theory**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weightage**:** **CWS** **15** **PRS** **0** **MTE** **35** **ETE** **50** **PRE** **0**

5. Credits**:** **3** 6. Semester**: Autumn/Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** Basic concepts of matrix theory and differential equations

9. Objective: To introduce the basic mathematical concepts of Control Theory such as controllability, observability, stability and optimal control.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1** | Mathematical models of control systems, State space representation, Autonomous and non autonomous systems, State, transition matrix, Peano series Solution of linear dynamical system. | **4** |
| **2** | Block diagram, Transfer function, Realization, Controllability, Kalman theorem, Controllability Grammian, Control computation using Grammian matrix, Observability, Duality theorems., Discrete control systems, Controllability and Observability results for discrete systems. | **10** |
| **3** | Companion form, Feedback control, State observer, Realization | **6** |
| **4** | Liapunov stability, Stability analysis for linear systems, Liapunov theorems for stability and instability for nonlinear systems, Stability analysis through Linearization, Routh criterion, Nyquist criterion, Stabilizability and detachability, | **8** |
| **5** | State feedback of multivariable system, Riccatti equation, Calculus of variation, Euler- Hamiltonian equations, Optimal control for nonlinear control systems, Computation of optimal control for linear systems. | **8** |

| | | |
|---|---|---|
| **6** | Control systems on Hilbert spaces, Semi group theory, Mild solution, Control of a linear system | **6** |
| | **Total** | **42** |

11. Suggested Books:

| **S. No.** | **Name of Books/Authors/Publishers** | **Year of publications / reprints** |
|---|---|---|
| **1.** | Barnett, S. "*Introduction to Mathematical Control theory*" Clarendon press Oxford | **1975** |
| **2.** | Dukkipati, R. V.,"*Control Systems*", Narosa | **2005** |
| **3.** | Nagrath I. J. and Gopal M., *"Control System Engineeering"*, New Age international | **2001** |
| **4.** | Datta, B., "*Numerical Methods for Linear Control Systems*", Academic press Elsevier | **2005** |
| **5.** | Kho , B. C.,"*Automatic Control System"*, Prentice hall | **2001** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **MATHEMATICS**

1. Subject Code: **MA-524** Course Title: **Integral Equations and Calculus of Variations**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**:** **CWS** 1 **PRS** **MTE** 35 **ETE** 50 **PRE** 0

5. Credits**:** 6. **15** ter**: B** **0** oject A **C** 3

8. Pre-requis

9. Objective: To introduce the methods and concepts to solve integral equations, and problems through calculus of variations.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | **Preliminary Concepts:** Definition and classification of linear integral equations. Conversion of initial and boundary value problems into integral equations. Conversion of integral equations into differential equations. Integro-differential equations. | **4** |
| 2. | **Fredholm I ntegral E quations:** Solution of integral equations with separable kernels, Eigenvalues and Eigenfunctions. Solution by the successive approximations, Numann series and resolvent kernel. Solution of integral equations with symmetric kernels, Hilbert-Schmidt theorem, Green's function approach. | **8** |
| **3.** | **Classical Fredholm Theory:** Fredholm method of solution and Fredholm theorems. | **4** |
| **4.** | **Volterra Integral Equations:** Successive approximations, Neumann series and resolvent kernel. Equations with convolution type kernels. | **4** |
| **5.** | **Solution o f i ntegral equations by transform methods:** Singular integral equations, Hilbert-transform, Cauchy type integral equations. | **6** |
| **6.** | **Calculus of V ariations:** Basic concepts of the calculus of variations such as functionals, extremum, variations, function spaces, the brachistochrone problem. Necessary condition for an extremum, Euler`s equation with the cases of one variable and several variables, Variational derivative. Invariance of Euler`s equations. Variational problem in parametric form. | **10** |
| **7.** | **General Variation:** Functionals dependent on one or two functions, Derivation of basic formula, Variational problems with moving boundaries, Broken extremals: Weierstrass –Erdmann conditions. | **6** |
| | **Total** | **42** |

**11. Suggested References/Books:**

| S. No. | Authors/Title/Publishers | Year of Publication /Reprint |
|---|---|---|
| **1.** | Jerry, Abdul J., Introduction to Integral Equations with applications, Clarkson University Wiley Publishers (II Edition) | **1999** |
| **2.** | Chambers, Ll. G., Integral Equations: A short Course, International Text Book Company Ltd. | **1976** |
| **3.** | Kanwal R. P., Linear Integral Equations, Birkhäuser Bosten, II Edition | **1997** |
| **4.** | Harry Hochstadt, Integral Equations, John Wiley & Sons | **1989** |
| **5.** | Gelfand, I. M., Fomin, S. V., Calculus of Vaiations, Dover Books | **2000** |
| **6.** | Weinstock Robert, Calculus of Variations With Applications to Physics and Enginering, Dover Publications, INC. | **1974** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Mathematics**

1. Subject Code: **MA-525** Course Title:**Robotics and Control**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weightage**:** **CWS** **15** **PRS** **0** **MTE** **35** **ETE** **50** **PRE** **0**

5. Credits**:** **3** 6. Semester**: Autumn/Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** Nil

9. Objective: To introduce the basic concepts of robot kinematics, dynamics and control.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1** | Introduction to Robotics, Robot manipulator, Applications. Simple planer model. Kinematics of two and three arm manipulators, Work space analysis, Fundamental rotation, Euler angles, Roll, Pitch law. Cylindrical and Spherical Coordinates general rotation and translation, Homogeneous transformation | **10** |
| **2** | Joint coordinate frames, Danawit-Hartimber Algorithm for fixing joint frames, Joint and link parameters of a robot manipulator, Arm matrix, Kinematics equation, Inverse Kinematics solution. | **10** |
| **3** | Differential translation and rotation, Derivatives of homogeneous transformations. Velocity and acceleration of a frame, The Jacobian and inverse Jacobian | **10** |
| **4** | Dynamics and Control: Lagrangian dynamic equations, Control of manipulator dynamics, Trajectory planning, Motion and grasp planning, Robotic vision. Some examples and simulations. | **12** |
| | **Total** | **42** |

11. Suggested Books:

| S. No. | Name of Books/Authors/Publishers | Year of publications |
|---|---|---|
| **1.** | Craig, J. J., "Introduction to Robotics" ,Addison-Wesley | **1999** |
| **2.** | Schilling, R. J.,"Fundamentals of Robotics" PHI publication | **2003** |
| **3.** | Au, Y. T.," Foundation of Robotics Analysis and Control" printice hall | **1990** |
| **4.** | Ghosal, A.,"Robotics:Fundamental Concepts and analysis" Oxford University press | **2006** |
| **5.** | Saeed B.N., "Introduction to Robotics" PHI | **2001** |

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics**

1. Subject Code: MA-526 Course Title: Soft Computing

2. Contact Hours: L: 3 T: 0 P: 0

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **15** PRS **0** MTE **35** ETE **50** PRE **0**

5. Credits: **3** 6. Semester: Autumn/Spring 7. Subject Area: DEC

8. Pre-requisite: Nil

9. Objective: To acquaint the students with the basic concepts of Soft Computing

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Introduction to Soft Computing, Historical Development, Definitions, advantages and disadvantages, solution of complex real life problems | **2** |
| **2.** | Neural Networks: Fundamentals, Neural Network Architectures, Feedforward Networks, Backpropagation Networks. | **10** |
| **3.** | Fuzzy Logic: Fuzzy Sets, Fuzzy numbers, Fuzzy Systems, membership functions, fuzzification, defuzzification. | **8** |
| **4.** | Genetic Algorithms: Generation of population, Encoding, Fitness Function, Reproduction, Crossover, Mutation, probability of crossover and probability of mutation, convergence. | **10** |
| **5.** | Hybrid Systems: Genetic Algorithm based Backpropagation Network, Fuzzy – Backpropagation, Fuzzy Logic Controlled Genetic Algorithms. Case studies. | **7** |
| **6.** | Case studies in Engineering | **5** |
| | **Total** | **42** |

11. Suggested Books

| S. No. | Title/Authors/Publishers | Year of Publication |
|---|---|---|
| **1.** | Jang, J-S. R., Sun,C-T, Mizutani, E.: “Neuro–Fuzzy and Soft Computing”, Prentice Hall of India. | **2002** |
| **2.** | Klir, G. J. and Yuan, B.: "Fuzzy Sets and Fuzzy Logic: Theory and Applications", Prentice Hall. | **1995** |
| **3.** | Rajasekaran, S. and Vijayalakshmi Pai, G.A.: “Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis and Applications”, Prentice Hall of India. | **2003** |
| **4.** | Sinha, N.K. and Gupta, M. M. : “Soft Computing and Intelligent Systems - Theory and Applications”, Academic Press. | **2000** |
| **5.** | Tettamanzi, A., Tomassini, M.: “Soft Computing: Integrating Evolutionary, Neural, and Fuzzy Systems”, Springer. | **2001** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Mathematics**

1. Subject Code: **MA-527** Course Title:**Stochastic Process**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weightage**:** **CWS** **15** **PRS** **0** **MTE** **35** **ETE** **50** **PRE** **0**

5. Credits**:** **3** 6. Semester**: Autumn/Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** Basic concepts probability and statistics

9. Objective: To introduce the basic concepts of stochastic processes

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1** | Introduction to stochastic processes | **2** |
| **2** | **Poisson Process:** Interarrival and waiting time distributions, conditional distributions of the arrival times, nonhomogeneous Poisson process, compound Poisson random variables and Poisson processes, conditional Poisson processes. | **8** |
| **4** | **Markov C hains:** Introduction and examples, Chapman-Kolmogorov equations and classification of states, limit theorems, transitions among classes, the Gambler's ruin problem, mean time in transient states, branching processes, applications of Markov chain, time reversible Markov chains, semi Markov processes. | **8** |
| **5** | **Continuous-Time M arkov C hains:** Introduction, continuous time Markov chains, birth and death processes, The Kolmogorov differential equations, limiting probabilities, time reversibility, applications of reversed chain to queueing theory. | **8** |
| **6** | **Martingales:** Introduction, stopping times, Azuma's inequality for martingales, submartingales, supermartingles, martingale convergence theorem. | **6** |

| | | |
|---|---|---|
| **7** | **Brownian Motion and other Markov Processes:** Introduction, hitting time, maximum variable, Arc sine laws, variations on Brownian motion, Brownian motion with drift, backward and forward diffusion equations. | **10** |
| | **Total** | **42** |

11. Suggested Books:

| **S. No.** | **Name of Books/Authors/Publishers** | **Year of publications / reprints** |
|---|---|---|
| **1.** | Ross, S. M., "Stochastic Processes" Wiley India Pvt. Ltd., 2nd Ed. | **2008** |
| **2.** | Brzezniak, Z. and Zastawniak, T., "Basic Stochastic Processes: A Course through Exercises", Springer | **1992** |
| **3.** | Medhi, J., "Stochastic Processes", New Age Science | **2009** |
| **4.** | Resnick, S.I., "Adventures in Stochastic Processes", Birkhauser | **1999** |
| **5.** | Hoel, P.G. and Stone, C.J., "Introduction to Stochastic Processes", Waveland Press | **1986** |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics**

1. Subject Code: **MA-621** Course Title: **Abstract Harmonic Analysis**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**:** **CWS** 15 **PRS** 00 **E** 35 50 0

5. Credits**:** 3 6. Semester**: Both** 7. Subject Area**: DEC**

8. Pre-requisite**:** Knowledge of Topology and Functional Analysis

9. Objective: To introduce the concepts of Harmonic analysis and representation theory

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| 1. | **Banach Algebra and Spectral Theory:** Basic Concepts, Gelfand theory, Nonunital Banach algebras, Spectral theorem, Theory of representation. | 9 |
| 2. | **Locally Compact Groups:** Topological groups, Haar measure, Modular functions, Convolutions, Homogenous spaces. | 8 |
| 3. | **Locally Compact Abelian Groups:** Dual Group, Pontragin Duality Theorem, Closed ideals, Spectral synthesis, Bohr compactification, Peter Weyl Theorem, Fourier Analysis. | 8 |
| 4. | **Basic Representation Theory:** Unitary Representation, Representation of a Group and its Group Algebra, Functions of Positive Type, Induced Representations, Frobenius Reciprocity Theorem, Pseudo measures, Imprimitivity. | 9 |
| 5. | **Structures in Representation Theory:** Group C* Algebra, Structure of Dual Space, Tenson, Products, Direct Integral Decomposition, Planchelar Theorem. | 8 |
| | **Total** | 42 |

11. Suggested Books:

| S. No. | Name of Authors/ Books/Publishers | Year of Publication/Reprint |
|---|---|---|
| 1. | Folland, G. B., A course in Abstract Harmonic Analysis, CRC Press | 1995 |
| 2. | Fell, J. M. G. and Doran R. S., Representation of * - Algebras, Locally Compact Groups and Banach Algebra bundles, Academic Press | 1988 |

| | | |
|---|---|---|
| 3. | Hewitt, E. and Ross, K. A., Abstract Harmonic Analysis, Springer. | 1993 |
| 4. | Rudin, W., Fourier Analysis on Groups, Interscience | 1990 |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTR: **MATHEMATICS**

1. Subject Code: **MA-622** Course Title: **Algebraic Number Theory**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weightage**:** **CWS** **15** **PRS** **0** **MTE** **35** **ETE** **50** **PRE** **0**

5. Credits**:** **3** 6. Semester**: Autumn/Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** Basic knowledge of Abstract Algebra

9. Objective: To introduce some basic concepts of algebraic number theory such as algebraic number fields, factorization, cyclotomic fields, ideal class groups etc.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Euclidean rings, Gaussian integers, Eisenstein integers, algebraic numbers, algebraic number fields, conjugate and discriminants, algebraic integers, integral bases, norms and traces, rings of integers, quadratic fields, cyclotomic fields | **8** |
| **2.** | Trivial factorization, factorization into irreducibles, examples of non-unique factorization into irreducible, prime factorization, Euclidean quadratic fields, consequence of unique factorization, some Diophantine equations, the Ramanujan-Nagell theorem, | **8** |
| **3.** | Factorization of Ideals – Dedekind domains, Fractional ideals, Prime factorization of ideals, norm of an ideal, non unique factorization in cyclotomic fields | **7** |
| **4.** | Lattices, the quotient torus, Minkowski theorem, the two-squares theorem, The four-square theorem, geometric representation of algebraic numbers, The space $L^{st}$. | **6** |
| **5.** | The class group, finiteness of the class-group, unique factorization of elements in an extension ring, factorization of a rational prime, Minkowski constants, class number calculations | **8** |
| **6.** | Dirichlet's unit theorem, units in real quadratic fields | **5** |
| | **Total** | **42** |

11. Suggested References/Books:

| S. No. | Title/Authors/Publishers | Year of Publication |
|---|---|---|
| **1.** | Stewart, I. N. and Tall, D. O.: "*Algebraic Number Theory and Fermat's Last Theorem*", A. K. Peters Ltd. (3rd Ed.) | **2002** |
| **2.** | Murty, R.and Esmonde, J., "*Problems in Algebraic Number Theory*", Springer (2nd Ed.) | **2004** |
| **3.** | Alaca, S. and Williams, K. S.: "*Introductory Algebraic Number Theory*", Cambridge University Press | **2004** |
| **4.** | Ireland, K. and Rosen, M.: "*A Classical Introduction to Modern Number Theory*", Springer (2nd Ed.) | **1990** |
| **5.** | Markus, D. A.: "*Number Fields*", Springer | **1995** |
| **6.** | Lang, S., "*Algebraic Number Theory* ", Springer (2nd Ed.) | **2000** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTR: **MATHEMATICS**
1. Subject Code: **MA-623** Course Title: **Algebraic Topology**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weightage**:** **CWS** **15** **PRS** **0** **MTE** **35** **ETE** **50** **PRE** **0**

5. Credits**:** **3** 6. Semester**: Autumn/Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** Basic knowledge of Group Theory and Topology

9. Objective: To introduce some basic concepts of algebraic topology such as homotopy, the fundamental group, deformation retracts etc.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Homotopy of paths, The Fundamental Group, Introduction to Covering Spaces, The Fundamental Group of the circle, Retractions and fixed points, Brouwer's fixed point theorem, Application to the Fundamental Theorem of Algebra, The Borsuk-Ulam Theorem, Deformation retracts, Homotopy equivalence, Fundamental group of product of spaces, Fundamental groups of the *n*-sphere $S^n$, the torus, the punctured plane, and the real projective n-space $RP^n$. | **14** |
| **2.** | Free Products of groups, Free groups, The Seifert - van Kampen Theorem, Fundamental group of a wedge of circles, Definition and construction of cell complexes, Application of van Kampen Theorem to cell complexes. | **8** |
| **3.** | Triangulations, Simplicial complexes, Barycentric subdivision, Simplicial mappings, homology groups and the simplicial approximation theorem, Calculations for cone complex, $S^n$ , The Euler-Poincare formula. The Lefschetz fixed point theorem. Singular homology groups, Topological invariance. The exact homology sequence. The Eilenberg Steenrod axioms. | **12** |
| **4.** | Covering spaces, unique lifting theorem, path-lifting theorem, covering homotopy theorem, Criterion of lifting of maps in terms of fundamental groups, Universal coverings and its existence, Special cases of manifolds and topological groups | **8** |
| | **Total** | **42** |

11. Suggested Books:

| S. No. | Title/Authors/Publishers | Year of Publication |
|---|---|---|
| **1.** | Munkres, J. R. : "*Topology*", Prentice Hall India (2nd Ed.) | **2000** |
| **2.** | Armstrong, M. A.: "*Basic Topology*", Springer International Edition | **2004** |
| **3.** | Hatcher, A.: "*Algebraic Topology*", Cambridge University Press | **2001** |
| **4.** | Massey, W. S.: "*A Basic Course in Algebraic Topology*", Springer International Edition | **2007** |
| **5.** | Rotman, J. J., "An *Introduction to Algebraic Topology*", Springer International Edition | **2004** |

.

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **MATHEMATICS**

1. Subject Code: **MA-624** Course Title: **Approximation Theory**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**: CWS** 15 **PRS** 0 **MTE** 35 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Autumn/Spring** 7. Subject Area**: DEC**

8. Pre-requisite**: Complex Analysis**

9. Objective: To provide the concepts of best approximation and various tools of approximation theory.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Concept of best approximation in a normed linear space, Existence of the best approximation, Uniqueness problem, Convexity-uniform convexity,strict convexity and their relations, Continuity of the best approximation operator. | **10** |
| **2.** | The Weierstrass theorem, Bernstein polynomials, Korovkin theorem, Algebraic and trigonometric polynomials of the best approximation, Lipschitz class, Modulus of continuity, Integral modulus of continuity and their properties. | **10** |
| **3.** | Bernstein's inequality, Jackson's theorems and their converse theorems, Approximation by means of Fourier series. | **12** |
| **4.** | Positive linear operators, Monotone operators, Simultaneous approximation, $L^p$ - approximation, Approximation of analytic functions. | **10** |
| | **Total** | **42** |

**11. Suggested Books:**

| S. No. | Authors/Title/Publishers | Year of Publication/ Reprints |
|---|---|---|
| **1.** | E. W. Cheney, E. W., "Introduction to Approximation Theory", AMS Chelsea Publishing Co. | **1981** |
| **2.** | Lorentz, G. G., "Bernstein Polynomials", Chelsea Publishing Co. | **1986** |
| **3.** | Natanson, I. P., "Constructive Function Theory Volume-I", Fredrick Ungar | **1964** |

| | | |
|---|---|---|
| | Publishing Co. | |
| **4.** | Mhaskar, H. M. and Pai, D. V., "Fundamentals of Approximation Theory", Narosa Publishing House | **2000** |
| **5.** | Timan, A. F., "Theory of Approximation of Functions of a Real Variable", Dover Publication Inc. | **1994** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTR: **MATHEMATICS**

1. Subject Code: **MA-625** Course Title: **Coding Theory**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weightage**:** **CWS** **15** **PRS** **0** **MTE** **35** **ETE** **50** **PRE** **0**

5. Credits**:** **3** 6. Semester**: Autumn/Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** Basic Abstract Algebra (Groups, Rings, Fields)

9. Objective: To give an introduction to basic concepts and techniques of coding theory such as block codes, linear codes, cyclic codes, bounds on codes, important families of algebraic codes, graphical codes, and convolutional codes.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | The communication channel, The coding problem, Block codes, Hamming metric, Nearest neighbour decoding, Linear codes, Generator and Parity-check matrices, Dual code, Standard array decoding, Syndrome decoding. | **8** |
| **2.** | Hamming codes, Golay codes, Reed-Muller codes, Codes derived from Hadamard matrices. | **5** |
| **3.** | Bounds on codes: Sphere packing bound, Perfect codes, Gilbert-Varshamov bound, Singleton bound, MDS codes, Plotkin bound.<br>Weight distributions of codes, MacWilliams identities. | **8** |
| **4.** | Algebra of polynomials, Residue class rings, Finite fields, Cyclic codes, Generator polynomial and check polynomial, Defining set of a cyclic code, BCH bound, Encoding and decoding of cyclic codes | **8** |
| **5.** | Hamming and Golay codes as cyclic codes, BCH codes, Reed-Solomon codes, Quadratic residue codes | **7** |
| **6.** | Graphical codes, Convolutional codes | **6** |
| | **Total** | **42** |

11. Suggested References/Books:

| S. | Title/Authors/Publishers | Year of |
|---|---|---|

| No. | | Publication |
|---|---|---|
| **1.** | MacWilliams, F. J. and Sloane, N. J. A.: "*The Theory of Error Correcting Codes*", North Holland | **1977** |
| **2.** | Ling, S. and Xing, C.: "*Coding Theory: A First Course*", Cambridge University Press | **2004** |
| **3.** | Roth, R. M.: "*Introduction to Coding Theory*", Cambridge University Press | **2006** |
| **4.** | Pless, V.: "*Introduction to The Theory of Error Correcting Codes*" John Wiley ($3^{rd}$ Ed.) | **1999** |
| **5.** | Huffman, W. C. and Pless, V.: "*Fundamentals of Error Correcting Codes*", Cambridge University Press | **2003** |
| **6.** | Lint, J. H. van: "*Introduction to Coding Theory*", Springer ($3^{rd}$ ed.) | **1998** |
| **7.** | Moon, T. K.: "*Error Correction Coding*", John Wiley & Sons | **2005** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTR: **MATHEMATICS**

1. Subject Code: **MA-626** Course Title: **Commutative Algebra**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weightage**:** **CWS** **15** **PRS** **0** **MTE** **35** **ETE** **50** **PRE** **0**

5. Credits**:** **3** 6. Semester**: Autumn/Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** Basic knowledge of Abstract Algebra

9. Objective: To introduce some basic concepts of commutative algebra such as localization, primary decomposition, integral extensions, valuations rings, and dimension theory.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Commutative rings, Ideals, Prime and maximal ideals, The spectrum of a ring, Nil radical and Jacobson radical, Operations on ideals, Extension and contraction of ideals, Affine algebraic set, Zariski topology | **6** |
| **2.** | Review of modules and submodules, Operations on submodules, Direct sum and product, Nakayama lemma, Exact sequences, Tensor product of modules | **5** |
| **3.** | Rings and modules of fractions, Local properties, Extended and contracted ideals in ring of fractions, Associated primes, Primary decomposition | **7** |
| **4.** | Properties of extension rings, integral extensions, going-up theorem, going-down theorem, Noether normalization, Hilbert's nullstellensatz | **7** |
| **5.** | Chain conditions, Noetherian rings, Primary decomposition in Noetherian rings, Artinian rings | **5** |
| **6.** | Valuation rings: General valuation, Discrete valuation rings, Dedekind domains, Fractional ideals | **6** |
| **7.** | Dimension theory: Graded rings and modules, Hilbert functions, Dimension theory of Noetherian local rings, Regular local rings | **6** |
| | **Total** | **42** |

11. Suggested References/Books:

| S. No. | Title/Authors/Publishers | Year of Publication |
|---|---|---|

| | | |
|---|---|---|
| **1.** | Atiyah, M. F. and Macdonald, I. G. : "*Introduction to Commutative Algebra*", Westview Press | **1994** |
| **2.** | Eisenbud, D.: "*Commutative Algebra with a view towards Algebraic Geometry*", Springer | **1995** |
| **3.** | Matsumura, H.: "*Commutative Ring Theory*", Cambridge University Press | **1986** |
| **4.** | Dummit, D. S. and Foote, R. M., "*Abstract Algebra*", John Wiley & Sons ($3^{rd}$ Edition) | **2003** |
| **5.** | Jacobson N., "*Basic Algebra Vol. II*", Dover Publications ($2^{nd}$ Ed.) | **2009** |
| **6.** | Lang S., "*Algebra*", Springer ($3^{rd}$ Ed.) | **2005** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MA-627** Course Title: **Dynamical Systems**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weightage**:** **CWS** **15** **PRS** **0** **MTE** **35** **ETE** **50** **PRE** **0**

5. Credits**:** **3** 6. Semester**: Autumn/Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **Nil**

9. Objective: To provide basic knowledge about the dynamical systems.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| 1. | **Linear D ynamical C ontinuous Sy stems:** First order equations, existence uniqueness theorem, growth equation, logistic growth, constant harvesting, Planar linear systems, equilibrium points, stability, phase space, n-dimensional linear systems, stable, unstable and center spaces | 8 |
| 2. | **Nonlinear autonomous Systems:** Motion of pendulum, local and global stability, Liapunov method, periodic solution, Bendixson's criterion, Poincare Bendixson theorem, limit cycle, attractors, index theory, Hartman Grobman theorem, non-hyperbolic critical points, center manifolds, normal forms, Gradient and Hamiltonian systems. | 14 |
| 3. | **Local Bifurcation:** Fixed points, saddle node, pitchfork trans-critical bifurcation, Hopf bifurcation, co-dimension. | 6 |
| 4. | **Discrete s ystems:** Logistic maps, equilibrium points and their local stability, cycles, period doubling, chaos, tent map, horse shoe map. | 6 |
| 5. | **Deterministic ch aos:** Duffing's oscillator, Lorenz System, Liapunov exponents, routes to chaos, necessary conditions for chaos. | 8 |
| | **Total** | 42 |

11. Suggested Books:

| S. No. | Name of Authors/ Books/Publishers | Year of Publication/Reprint |
|---|---|---|
| **1.** | Hirsch, M.W., Smale, S., Devaney, R.L. "Differential equations, Dynamical Systems and an Introduction to Chaos", Academic Press | **2008** |
| **2.** | Strogatz, S. H., "Nonlinear Dynamics and Chaos", Westview Press | **2008** |
| **3.** | Lakshmanan, M, Rajseeker, S., "Nonlinear Dynamics", Springer | **2003** |
| **4.** | Perko,L., "Differential Equations and Dynamical Systems", Springer | **1996** |
| **5.** | Hubbard J. H., West, B. H., "Differential equations: A Dynamical Systems Approach", Springer-Verlag | **1995** |
| **6.** | Kaplan D. , Gloss L., "Understanding Nonlinear Dynamics", Springer | **1995** |
| **7.** | Wiggins, S. "Introduction to applied Nonlinear Dynamical Systems and Chaos", Springer-Verlag | **1990** |

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: Mathematics

1. Subject Code: MA-628 Course Title: Evolutionary Algorithms

2. Contact Hours: L: 3 T: 0 P: 0

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **15** PRS **0** MTE **35** ETE **50** PRE **0**

5. Credits: **3** 6. Semester: Both 7. Subject Area: DEC

8. Pre-requisite: Nil

9. Objective: To acquaint students with basic concepts of Evolutionary Algorithms

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| 1. | **Genetic Algorithms:** Historical development, GA concepts – encoding, fitness function, population size, selection, crossover and mutation operators, along with the methodologies of applying these operators. Binary GA and their operators, Real Coded GA and their operators. | **12** |
| 2. | **Particle Swarm Optimization:** PSO Model, global best, Local best, velocity update equations, position update equations, velocity clamping, inertia weight, constriction coefficients, synchronous and asynchronous updates, Binary PSO. | **10** |
| 3. | **Memetic Algorithms:** Concepts of memes, Incorporating local search as memes, single and multi memes, hybridization with GA and PSO, Generation Gaps, Performance metrics. | **5** |
| 4. | **Differential Evolution:** DE as modified GA, generation of population, operators and their implementation. | **5** |
| 5. | **Artificial Bee Colony:** Historical development, types of bees and their role in the optimization process. | **5** |
| 6. | **Multi-Objective Optimization:** Linear and nonlinear multi-objective problems, convex and non – convex problems, dominance – concepts and properties, Pareto – optimality, Use of Evolutionary Computations to solve multi objective optimization, bi level optimization, Theoretical Foundations. | **5** |
| | Total | **42** |

11. Suggested Books

| S. No. | Title/Authors/Publishers | Year of Publication |
|---|---|---|
| **1** | Coello, C. A., Van Veldhuizen, D.A. and Lamont, G.B.: "Evolutionary Algorithms for solving Multi Objective Problems", Kluwer. | **2002** |
| **2** | Deb, K.: "Multi-Objective Optimization using Evolutionary Algorithms", John Wiley and Sons. | **2002** |
| **3** | Deb, K.: "Optimization for Engineering Design Algorithms and Examples", Prentice Hall of India. | **1998** |
| **4** | Gen, M. and Cheng, R.: "Genetic Algorithms and Engineering Design", Wiley, New York. | **1997** |
| **5** | Hart, W.E., Krasnogor, N. and Smith, J.E. : "Recent Advances in Memetic Algorithms", Springer Berlin Heidelberg, New York. | **2005** |
| **6** | Michalewicz, Z.: "Genetic Algorithms+Data Structures=Evolution Programs", Springer-Verlag, 3rd edition, London, UK. | **1992** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Mathematics**

1. Subject Code: **MA-629** Course Title:**Financial Mathematics**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weightage**:** **CWS** **15** **PRS** **0** **MTE** **35** **ETE** **50** **PRE** **0**

5. Credits**:** **3** 6. Semester**: Autumn/Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** Basic knowledge probability and statistics

9. Objective: To introduce the applications of mathematics and statistics in finance.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1** | Introduction- a simple market model : basic notions and assumptions, no– arbitrage principle. | **2** |
| **2** | Risk-free assets: time value of money, future and present values of a single amount, future and present values of an annuity, Intra-year compounding and discounting, continuous compounding. | **5** |
| **3** | Valuation of bonds and stocks: bond valuation, bond yields, equity valuation by dividend discount model and the P/E ratio approach. | **5** |
| **4** | Risky assets: risk of a single asset, dynamics of stock prices, binomial tree model, other models, geometrical interpretations of these models, martingale property. | **6** |
| **5** | Portfolio management: risk of a portfolio with two securities and several securities, capital asset pricing model, minimum variance portfolio, some results on minimum variance portfolio. | **8** |
| **6** | Options: call and put option, put-call parity, European options, American options, bounds on options, variables determining option prices, time value of options. | **6** |
| **7** | Option valuation: binomial model (European option, American option), Black-Scholes model (Analysis, Black-Scholes equation, Boundary and final conditions, Black-Scholes formulae etc). | **10** |

| | | |
|---|---|---|
| | **Total** | **42** |

11. Suggested Books:

| S. No. | Name of Books/ Authors/ Publishers | Year of publication |
|---|---|---|
| **1** | Capinski M. and Zastawniak T., "Mathematics for Finance- An introduction to financial engineering" , Springer | **2003** |
| **2** | Teall J. L. and Hasan I., "Quantitative methods for finance and investments", Blackwell publishing | **2002** |
| **3** | Hull J.C., "Options, futures and other derivatives", Pearson education | **2005** |
| **4** | Chandra P., "Financial Management – Theory and Practice", Tata Mcgraw Hill | **2004** |
| **5** | Wilmott P.,Howison S. and Dewynne J., "The mathematics of financial derivatives- A student introduction", Cambridge university press | **1999** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Mathematics**

1. Subject Code: **MA-630** Course Title:**Finite Element Methods**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weightage**:** **CWS** **15** **PRS** **0** **MTE** **35** **ETE** **50** **PRE** **0**

5. Credits**:** **3** 6. Semester**: Autumn/Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** Basic knowledge of numerical methods

9. Objective: To impart knowledge of finite element methods for solving ordinary and partial differential equations.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| 1. | Introduction to finite element methods, comparison with finite difference methods. | **2** |
| 2. | Methods of weighted residuals, collocations, least squares and Galerkin's method | **4** |
| 3. | Variational formulation of boundary value problems equivalence of Galerkin and Ritz methods. | **6** |
| 4. | Applications to solving simple problems of ordinary differential equations, | **6** |
| 5. | Linear, quadratic and higher order elements in one dimensional and assembly, solution of assembled system. | **6** |
| 6. | Simplex elements in two and three dimensions, quadratic triangular elements, rectangular elements, serendipity elements and isoperimetric elements and their assembly.discretization with curved boundaries | **8** |
| 7. | Interpolation functions, numerical integration, and modeling considerations | **5** |
| 8. | Solution of two dimensional partial differential equations under different Geometric conditions | **5** |
| | **Total** | **42** |

11. Suggested Books:

| S. No. | Name of Books/ Authors/ Publishers | Year of publication |
|---|---|---|
| **1** | Reddy J.N., "Introduction to the Finite Element Methods", Tata McGraw-Hill. | **2003** |
| **2** | Bathe K.J., Finite Element Procedures", Prentice-Hall. | **2001** |
| **3** | Cook R.D., Malkus D.S. and Plesha M.E., "Concepts and Applications of Finite Element Analysis", John Wiley. | **2002** |
| **4** | Thomas J.R. Hughes "The Finite Element Method: Linear Static and Dynamic Finite Element Analysis" | **2000** |
| **5** | George R. Buchanan "Finite Element Analysis", | **1994** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **MATHEMATICS**

1. Subject Code: **MA-631** Course Title: **Multivariate Techniques**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weightage**: CWS** **15** **PRS** **0** **MTE** **35** **ETE** **50** **PRE** **0**

5. Credits**:** **3** 6. Semester**: Autumn/Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **Mathematical Statistics**

9. Objective: To introduce two and multiple variable regression models, residual analysis and analysis of variance.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **4.** | Multivariate Normal Distribution: Joint and marginal densities, independence, estimation of mean vector and covariance matrix | **8** |
| **5.** | Causal relationships, Statistical models, Two variable linear regression models: Assumptions, methods for estimation of model, least square, minimum variance, best fit solutions, measure for quality of linear model, standard error | **6** |
| **6.** | Estimation, confidence intervals and tests of significance and prediction of new values | **4** |
| **7.** | Multiple Regression Analysis: graphical procedure, assumptions, methods for estimation of model, Determining Best Estimates. | **6** |
| **8.** | Test for significant overall regression, Partial F and multiple F Tests, Partial and multiple correlation and their relationship with multivariate normal distribution. | **4** |
| **9.** | Confounding and interaction in regression, regression diagnostics, residual analysis, collinearity. | **4** |
| **10.** | Polynomial Regression: second and higher order models their fitting and testing, Lac-of-fit Tests, orthogonal polynomials, Strategies for choosing a polynomial model problems. Selecting the Best Regression Equation. | **4** |
| **11.** | ANOVA: Basic concepts, Gauss Markoff theorem, One way classification, comparison of more than two means, statistical model and | **6** |

| | | |
|---|---|---|
| | analysis for one way layout, two way classification, statistical model and analysis for two way layout, analysis of variance using linear models<br>One way and Two way classification | |
| | **Total** | **42** |

11. Suggested Books:

| S. No. | Title/Authors/Publishers | Year of Publication/ Reprint |
|---|---|---|
| **1.** | Miller, I., and Miller, M., " John E. Freund's Mathematical Statistics with Applications", Prentice Hall PTR, 7th Ed. | **2006** |
| **2.** | Hogg, R. V. and Craig A., "Introduction to Mathematical Statistics", Pearson Education, 5th Ed. | **2006** |
| **3.** | Anderson, T. W., " An Introduction to Multivariate Statistical Analysis", John Wiley & Sons | **2003** |
| **4.** | Kleinbaun, D. G., Kupper, L. L., Muller, K. E. and Nizam, A., "Applied Regression Analysis and other Multivariable Methods", Duxbury Press | **1998** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MA-632** Course Title: **Optimal Control Theory**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**:** **CWS** 15 **PRS** 00 **MTE** 35 **ETE** 50 **PRE** 00

5. Credits**:** 3 6. Semester**: Both** 7. Subject Area**: DEC**

8. Pre-requisite**:** Nil

9. Objective: To introduce the optimal control, variational and dynamic programming approaches and some search techniques.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| 1. | **Optimal C ontrol Problems**: General optimal control problem, Formulation for economic growth, Resource depletion, Exploited populations, Advertising policies and rocket trajectories servo problems. | 8 |
| 2. | **Variational A pproach**: Necessary conditions for optimal control, Hamiltonian, Pontryagin's principle for continuous and for bounded and discontinuous controls, State inequality constraints, Switching curves, Switching curves, Trasversality conditions, Singular integrals in optimal control problems. | 12 |
| 3. | **Dynamic Programming A pproach**: Optimal control law, Principle of optimality and its applications to decision making in optimal control problems, Computational methods for solving optimal control problems, Some real life problems. | 12 |
| 4. | **Search Techniques**: Penalty and barrier search techniques | 5 |
| 5. | **Sensitivity analysis:** Sensitivity analysis in optimal control problems. | 5 |
| | **Total** | 42 |

11. Suggested Books:

| S. No. | Name of Authors/ Books/Publishers | Year of Publication/Reprint |
|---|---|---|
| **1.** | Burghes, D. N. and Graham, A., Introduction to control Theory including optimal control, John Wiley & Sons. | 1980 |
| **2.** | Canon, M. D., Culum, J.R., CC and Polak E., Theory of optimal control and Mathematical Programming, McGraw Hill. | 1970 |
| **3.** | Kirk, D.E., Optimal control theory-An introduction, Prentice Hall. | 1970 |
| **4.** | Lee, E. G., Markus L., Foundations of Optimal control theory, John Wiley & Sons. | 1967 |
| **5.** | Hull, D.G., Optimal control theory, Springer | 2005 |
| **6.** | Geering, H. P., "Optimal Control with Engineering Applications", Springer | 2007 |

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: Mathematics

1. Subject Code: MA- 633 Course Title: Parallel Computing

2. Contact Hours: L: 3 T: 0 P: 0

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **15** PRS **0** MTE **35** ETE **50** PRE **0**

5. Credits: **3** 6. Semester: Both 7. Subject Area: DEC

8. Pre-requisite: Nil

9. Objective: To acquaint the students with the basic concepts of Parallel Computing

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Introduction, history, temporal parallelism, data parallelism, combined temporal and data parallelism, data parallelism with dynamic and quasi-dynamic assignment, specialist data parallelism, coarse-grained specialized temporal parallelism, agenda parallelism. task dependencies and task graphs. | **7** |
| **2.** | Structures of parallel computers: classification of parallel computers based on data / instruction flow, coupling, mode of accessing memory, grain size, vector supercomputers, systolic processors. | **8** |
| **3.** | Shared memory parallel computers based on shared bus & intercommunication networks, direct and indirect networks. | **5** |
| **4.** | Message Passing Systems, MPI Programming, point-to-point communications, collective communications | **6** |
| **5.** | CUDA Programming, host, device, threads, blocks, indexing, synchronization, performance optimization. | **6** |
| **6.** | Performance evaluation, parallel balance point, concurrency, scalability, speedup, Amdahl's law, Gustafson's law, Sun and Ni's law. | **5** |
| **7.** | Parallel algorithms, matrix multiplication, system of linear equations, sorting, discrete Fourier transforms, numerical integration. | **5** |
| | **Total** | **42** |

11. Suggested Books

| S. No. | Title/Authors/Publishers | Year of Publication |
|---|---|---|
| **1.** | Aki, Selim G.: "The Design and Analysis of Parallel Algorithms", Prentice Hall, Englewood Cliffs, New Jersey. | **1989** |
| **2.** | Krik, David B. and Hwu, W.W.: "Programming Massively Parallel Processors - A Hands on Approach: Applications of GPU Computing Series", Elsevier Inc. | **2010** |
| **3.** | Pacheco, Peter S.: "Parallel Programming with MPI", Morgan Kaufmann Publishers, Inc., California. | **1997** |
| **4.** | Quinn, M. J.: "Parallel Computing: Theory and Practice", Tata McGraw Hill. | **1994** |
| **5.** | Rajaraman, V and Murthy, C. Siva Ram: "Parallel Computers Architecture and Programming", Prentice Hall of India. | **2000** |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics**

1. Subject Code: **MA-634** Course Title: **Orthogonal Polynomials and Special Functions**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**:** **CWS** 15 **PRS** 00 **MTE** 35 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Both** 7. Subject Area**: DEC**

8. Pre-requisite**:** Basic knowledge of Real and Complex Analysis

9. Objective: To give in-depth knowledge of various special functions and the concepts of Orthogonal polynomials

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| 1. | **Hypergeometric f unctions:** Solution of homogeneous linear differential equations of second order near an ordinary and regular singular point, their convergence and solutions for large values. Differential equations with three regular singularities, hypergeometric differential equations. Gauss hypergeometric function, elementary properties, contiguous relations, integral representation, linear and quadratic transformation and summation formulae. | 8 |
| 2. | **Analytic c ontinuation:** Barnes' contour integral representation. Confluent hypergeometric function and its elementary properties. | 4 |
| 3. | Generalized hypergeometric function $p\ q\ F$ and its elementary properties – linear and quadratic transformations, summation formula. | 4 |
| 4. | **Asymptotic s eries:** Definition, elementary properties, term by term differentiation, integration, theorem of uniqueness, Watson's lemma. Asymptotic expansion of 1F1 and 2F1 hypergeometric series. | 6 |
| 5. | **Orthogonal p olynomials**: Definition, their zeros, expansion in terms of orthogonal polynomials, three term recurrence relation, Christofel-Darboux formula, Bessel's inequality. Hermite, Laguerre, Jacobi and Ultraspherical polynomials: Definition and elementary properties. | 12 |
| 6. | Generating functions of some standard forms including Boas and Buck type. | 8 |

| | | |
|---|---|---|
| | Sister Celine's techniques for finding pure recurrence relation. Characterization: Appell, Sheffes and s-type characterization of polynomial sets. | |
| | **Total** | **42** |

11. Suggested Books:

| **S. No.** | **Name of Authors/ Books/Publishers** | **Year of Publication/Reprint** |
|---|---|---|
| 1. | T.S, Chihara - An introduction to orthogonal polynomials, Dover Publications | 2011 |
| 2. | M.E.H. Ismail, Classical and Quantum Orthogonal Polynomials in One variable, Cambridge University Press. | 2005 |
| 3. | F. Marcellan and W.Van Assche , Orthogonal polynomials and Special functions: Computation and Applications, Lecture Notes in Mathematics, Springer | 2006 |
| 4. | E.D. Rainville – Special Functions, MacMillan | 1960 |
| 5. | G. Szego – Orthogonal Polynomials, Memoirs of AMS | 1939 |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **MATHEMATICS**

1. Subject Code: **MA-635** Course Title: **Wavelet Theory**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weightage**:** **CWS** **15** **PRS** **0** **MTE** **35** **ETE** **50** **PRE** **0**

5. Credits**:** **3** 6. Semester**: Both** 7. Subject Area**: DEC**

8. Pre-requisite**:** Basic knowledge of Lebesgue theory and Functional analysis.

9. Objective: To provide basic knowledge of Fourier analysis, time frequency analysis and wavelet transform.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Review of basic concepts and theorems of Functional analysis and Lebesgue theory. | **4** |
| **2.** | Advanced Fourier Analysis: Fourier transform (F.T.) of functions in $L_1(R)$. Basic properties of F.T. of functions in $L_\infty(R)$. Inverse Fourier transform, Convolution, Approximate identity. Auto correlation of functions in $L_2(R)$, F.T. of functions in $L_1(R)\cap L_2(R)$. Various versions of Parseval`s identity (P. I.) of functions in $L_1(R)\cap L_2(R)$. Evaluation of improper integrals using P.I., Plancheral theorem. | **12** |
| **3.** | Trigonometric Fourier Series (TFS) of functions of $L_1[0, 2\pi]$ and its complex form. Dirichlet conditions, Gibbs phenomenon, modulus of continuity, integral modulus of continuity. Convergence of TFS in $L_1[0, 2\pi]$, Bessel`s inequality for functions of $L_2[0, 2\pi]$. Summability of TFS. The Poisson`s summation formula and its applications. | **6** |
| **4.** | **Time Frequency Analysis:** Window functions and their examples. Windowed functions. The Gabor transform STFS, the uncertainty principal, the classical Shanon sampling theorem, frames, exact and tight frames. | **10** |
| **5.** | **Wavelet Transform:** Isometric isomorphism between $\ell_2$ and $L_2[0, 2\pi]$, wavelet transform, wavelet series. Basic wavelets (Haar/Shannon/Daubechies), integral wavelet, orthogonal wavelets, multi-resolution analysis, reconstruction of wavelets and applications. | **10** |
| | **Total** | **42** |

11. Suggested Books:

| S. No. | Authors/Title/Publishers | Year of Publication/Reprint |
|---|---|---|
| **1.** | Chui, C. K., Introduction to Wavelet, Academic Press | **1992** |
| **2.** | Bachman, G. Narici, L., Beckenstein, E., Fourier and Wavelet Analysis, Springer | **2005** |
| **3.** | Chan, A. K., Chens Peng, Wavelet for Sensing Technology | **2003** |
| **4.** | Daubechies, I., Ten Lectures in Wavelets, SIAM | **1992** |
| **5.** | Koorniwinder, T.H., Wavelet: An Elementary Treatment of Theory and Applications, World Scientific Publication. | **1993** |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MAN-101** Course Title: **Introduction to Mathematical Sciences**

2. Contact Hours: **L: 2** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 15 **PRS** 00 35 50 0

5. Credits**:** 4 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**:** **None**

9. Objective: **To provide introductory knowledge to the students about mathematical sciences, commonly used terminologies and History of Mathematics.**

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | **Introduction** (with simple examples) to various branches of mathematics such as: Pure mathematics, Applied mathematics, Engineering mathematics, Statistics, Operations research, Mathematical modeling. | **4** |
| **2.** | **Geometry**: Basic structures, transformations among Cartesian, polar and parametric coordinates, curves, tracing and investigation of curves.. | **4** |
| **3.** | **History of Ancient mathematics**: Egypt and Mesopotamia, Number systems, Arithmetic and geometry, Hindu and Arabic, Invention of negative numbers and zero, development of algebra, roots of equations | **4** |
| **4.** | **Mathematics in Medieval period**: Distinct character of Greek Mathematics (geometry, logic, proof, axiomatic structure), Nature of problems and method of solutions, proof by contradiction, theory of incommensurables, method of exhaustion, reconsideration of infinity. | **8** |
| **5.** | **History of Modern Mathematics**: Development of calculus as the language of physics, Differential equations, Quantics, Theory of numbers, Introduction to the work of Srinivasa Ramanujan, Theory of functions, Probabilities and Least squares, Modern Geometry, Non-Euclidean geometry. | **8** |
| | **Total** | **28** |

11. Suggested Books:

| S. No. | Name of Authors/ Books/Publishers | Year of Publication/Reprint |
|---|---|---|
| 1. | C.B. Boyer, History of Mathematics, Wiley International Edition, New York. | 1968 |
| 2. | E. Carrucio, Mathematics and Logic in History and in Contemporary Thought, Aldine Publications company, Chicago. | 1964 |
| 3. | R. Courant, H. Robbins and I. Stewart, What is Mathematics? An elementary approach to ideas and methods, Oxford University Press, Oxford. | 1996 |
| 4. | Keith Devlin, Introduction to Mathematical Thinking, California. | 2012 |
| 5. | Howard Eves, An introduction to History of Mathematics, Holt, Reinhart and Winston, New York. | 1964 |
| 6. | G. H. Hardy and E. M. Wright, An Introduction to the Theory of Numbers, Oxford University Press. | 2008 |
| 7. | V. Lakshmikantham and S. Leela, Origin and History of Mathematics, Cambridge Scientific Publishers, Cambridge | 2005 |
| 8. | Sarju Tiwari, Mathematics in History, Culture, Philosophy and Science from ancient time to Modern age, Mittal Publications, New Delhi. | 1992 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MAN-102** Course Title: **Linear Algebra**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory : 3** **Practical : 0**
4. Relative Weightage**:** **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: DCC**
8. Pre-requisite**: Nil**
9. Objective: To introduce the basic concepts of vector spaces and linear transformations.
10. Details of Course:

| S. No. | Particulars | Contact Hours |
|---|---|---|
| 1 | **Vector S paces:** Vector space, subspace, sum of subspaces, linear combination, linear dependence and independence, basis and dimension, examples of infinite dimensional spaces, ordered bases and coordinates | 10 |
| 2 | **Linear T ransformation:** Basic definitions, rank-nullity theorem, matrix representation, algebra of linear transformations, change of basis, linear functional, Dual Spaces | 8 |
| 3 | **Canonical F orms:** Eigen-values of linear operators, Eigen-space, minimal polynomial, diagonalisation, invariant subspaces, Jordan canonical representation, Norm of a matrix, computation of a matrix exponential | 12 |
| 4 | **Inner Product Space:** Definition of inner product between two vectors, orthogonal and orthonormal vectors, normed space, Gram-Schmidt process for orthogonalisation, projection operator, quadratic forms, positive definite forms, Symmetric, Hermitian, orthogonal, unitary and Normal transformations/matrices. | 12 |
| | **TOTAL** | 42 |

11. Books Recommended:

| S.No | Name of Authors / Books / Publishers | Year of Publication/ Reprint |
|---|---|---|
| 1. | Hoffman, K. and Kunze, R., "Linear Algebra", 2nd edition, Pearson Education (Asia) Pvt. Ltd/ Prentice Hall of India | 2004 |
| 2. | Leon, S.J., "Linear Algebra with Applications", 8th Edition, Pearson | 2009 |
| 3. | Peter, J. Olever and Shakiban, C., "Applied Linear Algebra", 1st Edition , Prentice Hall | 2005 |
| 4. | Strang, G., "Linear Algebra and its Applications", 3rd edition, Thomson Learning Asia Pvt Ltd | 2003 |
| 5. | Sudan L., " Applied Linear Algebra ", Prentice Hall | 2001 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MAN-103** Course Title: **Introduction to Computer Programming**

2. Contact Hours: **L: 3** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**: CWS** 15 **PRS** 15 30 40 0

5. Credits**:** 4 6. Semester**: Autumn** 7. Subject Area**: ESC**

8. Pre-requisite**:** **None**

9. Objective: **To give the basic knowledge of computer programming**

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| 1. | **Basic Computer Fundamentals**: Introduction to computer systems; number system, integer, signed integer, fixed and floating point representations; IEEE standards, integer and floating point arithmetic; CPU organization, ALU, registers, memory, the idea of program execution at micro level. | 7 |
| 2. | **Basic Programming in C++**: Input/output; Constants, variables, expressions and operators; Naming conventions and styles; Conditions and selection statements; Looping and control structures (while, for, do-while, break and continue); Arrays; File I/O, header files, string processing; Pre-processor directives such as #include, #define, #ifdef, #ifndef; Compiling and linking. | 9 |
| 3. | **Programming through functional decomposition**: Design of functions, void and value returning functions, parameters, scope and lifetime of variables, passing by value, passing by reference, passing arguments by constant reference, recursive functions; Function overloading and default arguments; Library functions. | 8 |
| 4. | **Pointers**: Pointers; Dynamic data and pointers, dynamic arrays. | 3 |
| 5. | **Object Oriented Programming Concepts**: Data hiding, abstract data types, classes, access control; Class implementation-default onstructor, constructors, copy constructor, destructor, operator overloading, friend functions; Object oriented design (an alternative to functional decomposition) inheritance and composition; Dynamic binding and virtual functions; Polymorphism; Dynamic data in classes. | 12 |
| 6. | Introduction to data structures, use of pointers in linked structures. | 3 |
| | **Total** | 42 |

11. Suggested Books:

| S. No. | Name of Authors/ Books/Publishers | Year of Publication/Reprint |
|---|---|---|

| | | |
|---|---|---|
| 1. | H.M. Deitel and P.J. Deitel. C++ How to Program. Prentice Hall, 8th edition. | 2011 |
| 2. | B. Eckel. Thinking in C++ Volume 1 & 2. Prentice Hall, 2nd edition. | 2003 |
| 3. | I. Koren. Computer Arithmetic Algorithms. A.K. Peters Ltd., 2nd edition | 2001 |
| 4. | S.B. Lippman, J. Lajoie, and B.E. Moo. The C++ Primer. Addison-Wesley Professional, 5th edition | 2012 |
| 5. | S. Oualline. Practical C++ Programming. O'Reilly Media, 2nd edition. | 2003 |
| 6. | S. Prata. C++ Primer Plus. Sams, 5th edition. | 2004 |
| 7. | W. Stallings. Computer Organisation and Architecture: Designing for Performance. Prentice-Hall, 7th edition. | 2005 |
| 8. | B. Stroustrup. The C++ Programming Language. Addison-Wesley, 3rd edition. | 1997 |
| 9. | R. Lafore. Object-Oriented Programming in C++. Sams Publishing, 4th edition. | 2001 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MAN-104** Course Title: **Real Analysis- I**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weightage**:** **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: DCC**
8. Pre-requisite**: Nil**
9. Objective: To provide the basic properties of functions of a real variable.
10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Real number system, ordering, bounded sets, order completeness axiom, mathematical induction, well ordering principle; Archimedian property, Dedekind's theorem, complete ordered field, limit point of a set, Bolzano-Weierstrass theorem, open and closed sets, compact sets and Heine-Borel theorem. | **8** |
| **2.** | Sequences, Cauchy's first and second limit theorems, Cauchy sequences, Cauchy criterion for convergent sequences, bounded and monotonic sequences, Euler's constant, subsequences, limit superior and limit inferior. Series of real valued functions and their Tests for convergence. | **6** |
| **3.** | Limit and continuity, uniform continuity, monotonic functions, functions of bounded variation, absolutely continuous functions, Taylor's theorem (finite form), Lagrange's form of remainder. | **7** |
| **4.** | Sequences and series of real valued functions, their point-wise, absolute and uniform convergence, Cauchy's general principle of uniform convergence, continuity of the limit (sum) function, differentiation and integration of the sequences and series of functions, Weierstrass approximation theorem. | **6** |
| **5.** | Riemann integration, Darboux's theorem, necessary and sufficient conditions for integrability, functions defined by integrals, fundamental theorem of calculus, first and | **8** |

| | | |
|---|---|---|
| | second mean value theorems of integral calculus | |
| **6.** | Metric spaces, open and closed sets, interior, closure and limit points of a set, subspaces, continuous functions on metric spaces, convergence in a metric space, complete metric spaces. | **7** |
| | **Total** | **42** |

11. Suggested Books:

| **S.No.** | **Name of Authors / Books / Publishers** | **Year of Publication/ Reprint** |
|---|---|---|
| 1. | Royden. H.L. and Fitzpatrick. P.M., Real Analysis, Prentice Hall India Pvt. Ltd. | 2010 |
| 2. | Apostol, T. M., Mathematical Analysis, Narosa Publishing House. | 2002 |
| 3. | Lang. S., Real and Functional Analysis, Springer-Verlag. | 1993 |
| 4. | Rudin. W., Principles of Mathematical Analysis**,** McGraw-Hill Book Company. | 1976 |
| 5. | Goldberg, R.R., Methods of Real Analysis, Oxford and IBH Publishing company Pvt. Ltd. | 1970 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MAN-106** Course Title: **Data Structures**

2. Contact Hours: **L: 3** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weightage**:** **CWS: 15** **PRS: 15** **MTE: 30** **ETE: 40** **PRE: 0**

5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**: Nil**

9. Objective: To impart the knowledge of basic Data Structures such as Arrays, Stacks, Queues, Linked Lists, Trees, lists and Graphs.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1** | Introduction to data structures. Arrays: One and two dimensional arrays, storage allocations. String representation. Implementation of abstract data types (ADT). | **3** |
| **2** | Stacks: LIFO structure, push, pop, create, delete and empty stack. Queues: FIFO structure, operations on queues, priority queues, circular queues. Linear lists, list v/s array, internal pointer & external pointer, head, tail of a list, null list, length of a list. | **5** |
| **3** | Linked Lists: nodes, linked list data structure, algorithms: insert, delete and retrieve node, create, search, print, append linked list, array of linked lists, header nodes, circularly-linked list, doubly linked list: insertion, deletion. | **8** |
| **4** | Binary trees: definition, array, linked and threaded representations, traversal, (Pre, Post and Symmetric order), expression trees (Infix, Prefix and Postfix). | **6** |
| **5** | Sorting: Selection sort, bubble sort, exchange sort, quick sort, heap sort and merge sort. Analysis of sorting techniques. Searching: sequential search, binary search, search trees AVL trees, M-way search trees, B trees, hash tables, hashing functions, collision resolution techniques. | **8** |
| **6** | General lists: Representations, operations, dynamic storage management, garbage collection, compaction. | **4** |
| **7** | Graphs: array and linked representation, operations: add, delete and find vertex, add, delete edge, traverse graph (depth-first, breadth-first). Networks: minimum spanning tree, shortest path algorithm (Dijkstra's algorithm and Kruskal's algorithm). | **8** |
| | **Total** | **42** |

## 11. List of Data Structure Practical

Write C++ programs to implement the following:

1. Traversal, insertion, deletion in a linear array.
2. Stacks using arrays.
3. Linear Queue using arrays.
4. Circular Queue using arrays
5. Stacks and Queues using linked list.
6. Singly Linked circular List.
7. Doubly Linked List.
8. Polynomial Arithmetic using linked list.
9. Binary Tree Traversal (pre, post and symmetric order)
10. Sequential Search and Binary Search.
11. Binary Search Tree.
12. Insertion sort, Exchange sort, Selection sort
13. Quick sort.
14. Heap Sort.

## 12. Suggested Books:

| S.No. | Name of Authors / Books / Publishers | Year of Publication/ Reprint |
|---|---|---|
| 1 | Langman, Y., Augenstein, M.; Tennenbaum A.M. Data Structure Using C and C++. Prentice Hall of India. | 1998 |
| 2 | Sahni S., Data Structures Algorithms and Applcations in C++, McGraw Hill | 2005 |
| 3 | Dale N., C++ Plus Data Structures. Narosa Publications. | 2000 |
| 4 | Tenenbaum A. M., Data Structures Using C, Pearson Edn, India. | 1990 |
| 5 | Kruse Robert L., Ryba Alexander J., Data Structures and Program Design in C++ | 1998 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Physics**

1. Subject Code: **PHN-001** Course Title: **Physics Department**
2. Contact Hours: **L: 3** **T : 0** **P: 2**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weightage**:** **CWS: 15** **PRS: 25** **MTE: 20** **ETE: 40** **PRE: 0**
5. Credits**: 4** 6. Semester**: Autumn** 7. Subject Area**: BSC**
8. Pre-requisite**: None**
9. Objective: **To familiarize students with the basic principles of mechanics**
10. Details of Course:

| S.No. | Contents | Contact Hours |
|---|---|---|
| 1 | **STATICS OF PARTICLES.** Vectorial representation of forces and moments- Vector Operation-Concepts of Particles and Rigid bodies – Composition of concurrent forces in plane free body Diagram – Equilibrium of Rigid bodies in Two and three dimensions-Moment of a force about a point and about an axis-Couple moment-Reduction of a force system to a force and a couple | **8** |
| 2 | **PROPERTIES OF SURFACES, MOMENTS AND PRODUCTS OF INERTIA** Definition Moment of Inertia for areas-Parallel axis theorem –Perpendicular axis theorem-Moment of inertia for composite area-product of inertia form an area-mass moment of inertia | **6** |
| 4 | **FRICTION** Laws of coulomb friction- Coefficient of Friction-Dry Friction-sliding Friction-Ladder friction-Belt friction – Rolling Resistance. | **4** |
| 5 | **KINEMATICS OF PARTICLES** Principle of virtual work for a particle and rigid body-condition for equilibrium for a conservative system, stability-particle dynamics in rectangular coordinate, cylindrical coordinate and in terms of path variables-General motion of system of particles- | **8** |
| 6 | **WORK ENERGY METHODS, IMPULSE AND MOMENTUM** Work Energy Method-Conservation of Energy-Impulse and Momentum Relation-Impulsive Force-Impact force-Conservation of momentum – Moment of Momentum Equation. | **8** |
| 7 | **RIGID BODY MOTION;** Translation and rotation of rigid bodies- Derivative of a vector fixed in moving reference-General relationship between time derivative of a vector for different references-Moment of momentum equation-kinetic energy of rigid body-work and energy relations-Euler's equation of motion-Three dimensional motion about a fixed point | **8** |
| | **TOTAL** | **42** |

**List of experiments:**

1. Study of magnetic field of a pair of coils in Helmholtz arrangement
2. Determination of e/m
3. Determination of first excitation potential of a gas by Frank-Hertz experiment
4. Determination of Stefan's constant
5. Determination of Planck's constant by radiation
6. To study and verify Malus' law
7. Study of Polarization of light using quarter wave plate
8. Determination of Brewster's angle at glass-air interface
9. Determination of with of a slit by single-slit diffraction pattern
10. Four probe method of finding resistivity of semiconductor
11. Quinck's Method for determining mass susceptibility
12. Wavelength of Na light by Newton's ring method

11. Suggested Books:

| S.No. | Title/Authors/Publishers | Year of Publication |
|---|---|---|
| 1. | Shames I.H. and Rao G.K., "Engineering Mechanics-Statics and Dynamics" ,4 Edition, Pearson Education | 2006 |
| 2. | Beer F.P and Johnson E.R., "Vector Mechanics for Engineers- Statics and Dynamics",9 Edition, Tata McGraw-Hill Publishing Company | 2010 |
| 3. | Pytel A. and Kiusalaas J., " Engineering Mechanics: Statics" 3rd Edition, Cengage Learing | 2010 |
| 4. | Pytel A. and Kiusalaas J., " Engineering Mechanics: Dynamics"3rd Edition Cengage Learing | 2010 |
| 5. | Hibberler R.C and Gupta A., Engineering Mechanics,", 12th Edition, Pearson Education | 2012 |
| 6. | Meriam J.L. and Kraige L.G., "Engineering Mechanics: Statics", 6th Edition, John Willey and Son,s | 2012 |
| 7. | Meriam J.L., and Kraige L.G., "Engineering Mechanics: Dynamics", 6th Edition , John Willey and Son's | 2012 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MAN-201** Course Title: **Complex Analysis-I**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory:3** **Practical:0**

4. Relative Weightage**: CWS:25** **PRS:0** **MTE:25** **ETE:50** **PRE:0**
5. Credits**:4** 6. Semester**: Autumn** 7. Subject Area**: DCC**
8. Pre-requisite**: Nil**
9. Objective: To provide knowledge about the analytical aspects of functions of one complex variable.
10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | **Introduction:** Algebra of Complex Numbers, inequalities. Stereographic Projection, Topological structure of Complex Plane, Simply connected and multiply connected domains. | **2** |
| **2.** | **Analytic F unctions**: Functions of a complex variable. Limits, continuity, uniform continuity, differentiability and analyticity of functions, C-R equations, necessary and sufficient conditions, applications to the problems of potential flow, Harmonic functions, Harmonic conjugates, Milne's method. Sequences, Series, Uniform convergence, power series, Hadamard's formula for the radius of convergence, elementary functions, exponential, trigonometric and hyperbolic functions and their identities in the complex plane, multiple valued functions, logarithmic functions and functions with complex exponent. | **10** |
| **3.** | **Complex i ntegration:** Rectifiable arcs, contours, complex line integration, Cauchy's theorem for simply and multiply connected domains, Cauchy's integral formula for the derivatives of an analytic function, Winding Numbers, Cauchy's estimate, Morera's theorem, Liouville's theorem, Fundamental theorem of Algebra. Maximum modulus principle, Schwarz Lemma, Taylor series, Laurent series, Zeros and poles of a function, Meromorphic function. | **8** |
| **4.** | **Residue C alculus:** The residue at a singularity, Residue theorem, the argument principle, Rouche's theorem, contour integration and its applications to improper integrals, evaluation of a real integrals, improper integrals involving sines and cosines, definite integrals involving sines and cosines, integration through branch cut. | **6** |
| **5.** | **Conformal M apping:** Definition of Conformal and Bilinear transformations, Cross ratio, the mappings from disc to disc, disc to half plane and half plane to half plane. Mapping of elementary transformations. | **7** |
| **6.** | **Applications:** Applications of conformal mapping to steady temperature, electrostatic potential, two–dimensional fluid flow, stream function. Schwarz-Christoffel transformations and their applications, Poisson formula, Dirichlet problem in the unit disc, Dirichlet problem in the half plane, Neumann problem for the disc and the half plane. | **9** |
| | **Total** | **42** |

11. Suggested Books:

| S. No. | Name of Authors/ Books/Publishers | Year of Publication/Reprint |
|---|---|---|
| 1. | Churchill, J. W. and Brown, R. V., "Complex Analysis", Mcgraw-Hill. | 2009 |
| 2. | Gamelin, T. W., "Complex Analysis", Springer-Verlag | 2001 |
| 3. | Greene R., and Krantz, S. G., "Function Theory of One Complex Variable", 3rd Edition, GSM, Vol. 40, American Mathematical Society. | 2006 |
| 4. | Kreyszig, E., "Advanced Engineering Mathematics", Wiley, New York | 2009 |
| 5. | Lang, S., "Complex Analysis", Springer –Verlag. | 2003 |
| 6. | Mathews, J. H. and Howell, R. W., "Complex Analysis for Mathematics and Engineering", Narosa | 2009 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MA-202** Course Title: **Transform Techniques**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory:3** **Practical:0**

4. Relative Weightage**: CWS:25** **PRS:0** **MTE:25** **ETE:50** **PRE:0**

5. Credits**:4** 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**: Nil**

9. Objective: To provide knowledge of various mathematical transformations and their applications.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | **Laplace T ransform:** Laplace of some standard functions, Existence conditions for the Laplace Transform, Shifting theorems, Laplace transform of derivatives and integrals, Inverse Laplace transform and their properties, Convolution theorem, Initial and final value theorem, Laplace transform of periodic functions, error functions, Heaviside unit step function and Dirac delta function, Applications of Laplace transform to solve ODEs and PDEs. | **10** |
| **2.** | **Finite L aplace T ransform:** Definition and properties, Shifting and scaling theorem. | **5** |
| **3.** | **Z-Transform:** Z–transform and inverse Z-transform of elementary functions, Shifting theorems, Convolution theorem, Initial and final value theorem, Application of Z-transforms to solve difference equations. | **5** |
| **4.** | **Hankel T ransform:** Basic properties of Hankel Transform, Hankel Transform of derivatives, Application of Hankel transform to PDE. | **4** |
| **5.** | **Mellin Transform:** Definition and properties of Mellin transform, Shifting and scaling properties, Mellin transforms of derivatives and integrals, Applications of Mellin transform. | **5** |
| **6.** | **Fourier series:** Trigonometric Fourier series and its convergence. Fourier series of even and odd functions, Gibbs phenomenon, Fourier half-range series, Parseval`s identity, Complex form of Fourier series. | **5** |
| **7.** | **Fourier T ransforms:** Fourier integrals, Fourier sine and cosine integrals, Complex form of Fourier integral representation, Fourier transform, Fourier transform of derivatives and integrals, Fourier sine and cosine transforms and their properties, Convolution theorem, Application of Fourier transforms to Boundary Value Problems. | **8** |
| | **Total** | **42** |

11. Suggested Books:

| S.No. | Name of Authors / Books / Publishers | Year of Publication/ Reprint |
|---|---|---|
| **1.** | Kreyszig, E., "Advanced Engineering Mathematics", John Wiley & Sons | 2011 |
| **2.** | Jain, R. K. and Iyenger, S. R. K., "Advanced Engineering Mathematics", Narosa Publishing House | 2009 |
| **3.** | Hildebrand F. B., "Methods of Applied Mathematics", Courier Dover Publications | 1992 |
| **4.** | Debanth L. and Bhatta D., Integal Tranforms and Their Applications, $2^{nd}$ edition, Taylor and Francis Group | 2007 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MAN-203** Course Title: **Discrete Mathematics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory 3** **Practical0**

4. Relative Weightage**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**: Nil**

9. Objective: To provide the basic knowledge about discrete mathematics.

10. Details of Course:

| S.No. | Contents | Contact Hours |
|---|---|---|
| **1** | Logic and Proofs: Proposition, predicate logic, logic connectives, methods of proofs. Mathematical induction | **06** |
| **2** | Relation and Function: Definitions and properties, pigeonhole principle, extended pigeonhole principle, equivalence relations and equivalence classes. representation of relations by binary matrices and digraphs; operations on relations. closure, Warshall's algorithm, discrete numeric functions, growth of functions, big O, big $\Theta$, hash function. | **10** |
| **3** | Partial Order Relations: Partially ordered sets, lattices, isomorphism of lattices | **05** |
| **4** | Boolean algebra and Boolean functions, different representations of Boolean functions, application of Boolean functions to synthesis of circuits, circuit minimization and simplification, Karnaugh map. | **08** |
| **5** | Languages and grammars, Finite state machines, Finite state automata. | **05** |
| **6** | Recurrence Relation: Linear recurrence relations with constant coefficients, homogeneous and non-homogeneous relations, discussion of several special cases to obtain particular solutions. Generating functions, solution of linear recurrence relations using generating functions. Some recursive algorithms. | **08** |
| | **Total** | **42** |

11. Suggested Books:

| S.No. | Name of Authors / Books / Publishers | Year of Publication/ Reprint |
|---|---|---|
| **1.** | Kenneth, K. R., Discrete Mathematics and its Applications, 7th Ed., Tata McGraw Hill, | **2012** |
| **2.** | Liu, C. L., Elements of Discrete Mathematics, Tata McGraw Hill | **2007** |
| **3.** | Johnsonbaugh, R., Discrete Mathematics, 6th Ed., Maxwell Macmillan International | **2006** |
| **4.** | Mott, J.L., Kandel, A. and Baker, T.P., Discrete Mathematics for Computer Scientists and Mathematicians, Prentice Hall India Pvt Ltd | **2001** |
| **5.** | Kolman, B., Busby, R. and Ross, S.C., Discrete Mathematical Structure, 6th Ed., Pearson | **2008** |

# INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

**Name of Department:** **Department of Mathematics**

Subject Code: **MAN-204** Course Title: **Database Management Systems**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory:3** **Practical: 0**

4. Relative Weightage**:** **CWS:25** **PRS:0** **MTE:25** **ETE:50** **PRE:0**

5. Credits**:4** 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**:** A course on Programming languages

9. Objective: To impart the knowledge of basic Data Base Management Systems

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1** | Purpose of Database System, Views of data, Data Models, Database Languages-Database System Architecture, Database users and Administrator, Entity Relationship model (E-R model ) – E-R Diagrams, Introduction to relational databases. | **8** |
| **2** | The relational Model – The catalog Types, Keys, Relational Algebra, Domain Relational Calculus, Tuple Relational Calculus, Fundamental operations, Additional Operations, SQL fundamentals - Integrity, Triggers, Security, Advanced SQL features, Embedded SQL, Dynamic SQL, Missing Information, Views, Introduction to Distributed Databases and Client/Server Databases. | **10** |
| **3** | PL/SQL- Basic and Advanced Concepts. | **8** |
| **4** | Functional Dependencies – Non-loss Decomposition, Functional Dependencies – First, Second, Third Normal Forms, Dependency Preservation , Boyce/Codd Normal Form, Multi-valued Dependencies and Fourth Normal Form – Join Dependencies and Fifth Normal Form. | **8** |
| **5** | Transaction Concepts - Transaction Recovery, ACID Properties, System Recovery, Media Recovery, Two Phase Commit, Save Points – SQL Facilities for recovery, Concurrency, Need for Concurrency, Locking Protocols, Two Phase Locking, Intent Locking, Deadlock, Serializability – Recovery Isolation Levels – SQL Facilities, for Concurrency. | **8** |
| | **Total** | **42** |

11. Suggested Books:

| S.No. | Name of Authors / Books / Publishers | Year of Publication/ Reprint |
|---|---|---|
| 1. | Silberschatz, A., Korth, H. F., Sudharshan, S., “Database System, Concepts”, Sixth Edition, Tata McGraw Hill | 2011 |
| 2. | Date, C. J., Kannan, A., Swamynathan, S., “An Introduction to Database Systems”,Eighth Edition, Pearson Education | 2006 |
| 3. | Elmasri, R. and Navathe, S. B., “Fundamentals of Database Systems”, FourthEdition , Pearson / Addision wesley | 2007 |
| 4. | Bhattacharya, P. and Majumdar, A., "Introduction to Database Management Systems", Tata McGraw Hill | 2001 |
| 5. | Desai, B. C., "Introduction to Database Systems" West Group, $11^{th}$ Ed. | 1990 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MAN-205** Course Title: **Ordinary and Partial Differential Equations**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory:3** **Practical :0**

4. Relative Weightage**:** **CWS :25** **PRS:0** **MTE:25** **ETE:50** **PRE:0**

5. Credits**:4** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**:** **Nil**

9. Objective: To provide basic concepts of differential equations and their solutions.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | **Introduction t o Differential E quations:** Formation of differential equations. Basic definitions (linearity, order, homogeneous and non-homogeneous, explicit and implicit solution, general solution, particular solution). Existence and uniqueness theorem for linear ODE. | **3** |
| **2.** | **Review of F irst or der O DE:** Separable equations, ODE with homogenous coefficients. Exact equations. Integrating factors. ODE with linear coefficients, Bernoulli equation. | **2** |
| **3.** | **Second an d H igher or der O DE:** Linear independence of functions, Wronskian and its basic properties. Solution of homogeneous and non-homogeneous linear ODE with constant coefficients using method of undetermined coefficients and inverse operator method. Equation with variable coefficients, Euler-Cauchy equations, Variation of parameters, Reduction of order. Solution of second order differential equations by changing dependent and independent variables. | **8** |
| **4.** | **Series Solution:** Power series solution of second order homogeneous ODE, ordinary points, singular points, Frobenius series solution, Legendre and Bessel's equation through examples. Elementary properties of Legendre polynomial and Bessel functions. | **9** |
| **5.** | **Partial D ifferential E quations:** Introduction, Curves and surfaces. Formation of PDE, Classification of solutions (Complete, general and singular). | **2** |
| **6.** | **First or der PDE:** Classification of first order PDE, Lagrange`s method to solve first order PDE. Integral surface passing through a | **9** |

| | | |
|---|---|---|
| | given curve. Compatibility, Charpit's method to solve first order nonlinear PDE. Special types of first order PDE | |
| **7.** | **Second or der P DE:** Solutions of linear PDE with constant coefficients using differential operators, reducible and irreducible non-homogeneous linear PDE, Homogeneous linear PDE with constant coefficients. Classification of second order PDE, Canonical forms. | **9** |
| | Total | **42** |

11. Suggested Books:

| **S.No.** | **Name of Authors / Books / Publishers** | **Year of Publication/ Reprint** |
|---|---|---|
| 1 | Simmons, G. F. , "Differential Equations " , McGraw-Hill, 2nd Edition | 1991 |
| 2. | Hildebrand F. B., "Methods of Applied Mathematics", Courier Dover Publications | 1992 |
| 3. | Tenenbaum, M. and Polard, H., "Ordinary Differential Equations", Dover Publications | 1985 |
| 4. | Sneddon, I. N., "Elements of Partial Differential Equations", McGraw-Hill Book Company | 1988 |
| 5. | Rao, K. S., "Introduction to Partial Differential Equations", PHI Learning Pvt. Ltd. (2nd Edition) | 2010 |
| 6. | Amarnath, T., "An Elementary Course in Partial Differential Equations", Narosa Publishing House (2nd Edition) | 2012 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MAN-206** Course Title: **Graph Theory**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory:3** **Practical:0**

4. Relative Weightage**: CWS:25** **PRS:0** **MTE:25** **ETE:50** **PRE:0**

5. Credits**:4** 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**:** **Nil**

9. Objective: To introduce the basic concepts of graph theory and its applications

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | **Introduction to Graphs:** Definition of a graph, finite and infinite graphs, incidence of vertices and edges, types of graphs, subgraphs, walks, trails, paths, cycles, connectivity, components of a graph, Eulerian and Hamiltonian graphs, travelling salesman problem, vertex and edge connectivity, matrix representation of graphs, incidence and adjacency matrices of graphs. | **10** |
| **2.** | **Trees an d F undamental C ircuits:** Definition and properties of trees, rooted and binary trees, counting trees, spanning trees, weighted graphs, minimum spanning tree, fundamental circuit, cut set, separability, network flows. | **8** |
| **3.** | **Vector S paces A ssociated w ith G raphs:** Galois fields, Vector spaces associated with graphs, orthogonal vectors and spaces. | **4** |
| **4.** | **Planar Graphs and Graph coloring:** Planar graphs, Kuratowski's graphs, detection of planarity, Euler's formula for planar graphs, geometric and combinatorial duals of a planar graphs, coloring of graphs, chromatic numbers, chromatic polynomial, chromatic partitioning, Four color theorem. | **7** |
| **5.** | **Directed G raphs:** Types of digraphs, digraphs and binary relations, directed paths and connectedness, Euler digraphs, de Brujin sequences, tournaments | **5** |
| **6.** | **Ramsey Theory:** Introduction to Ramsey theory, Ramsey numbers, Ramsey theorem. | **3** |
| **7.** | **Enumerations:** Types of enumerations, Polya theory of enumeration and its applications. | **5** |
| | **Total** | **42** |

11. Suggested Books:

| S.No. | Name of Authors / Books / Publishers | Year of Publication/ Reprint |
|---|---|---|
| 1. | Deo N., “Graph Theory with Applications to Engineering and Computer Science”, Prentice Hall India | 2004 |
| 2. | West D. B., "Introduction to Graph Theory ", Prentice Hall India (2nd Ed.) | 2009 |
| 3. | Clark J. and Holton J. A.,"A First Look at Graph Theory", World Scientific | 1991 |
| 4. | Wilson R. J., “Introduction to Graph Theory”, Pearson Education (4th Ed.) | 1996 |
| 5. | Chartrand G. and Zhang P., "Introduction to Graph Theory", Tata McGraw Hill | 2007 |
| 6. | Aldous J. M., Wilson R. J. and Best S., “Graphs and Applications: An Introductory Approach”, Springer | 2003 |
| 7. | Deistel R., “Graph Theory”, Springer (4th Ed.) | 2010 |
| 8. | Bondy J. A. and Murty U. S. R., “Graph Theory”, Springer | 2011 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTR: **Department of Mathematics**

1. Subject Code: **MAN-291** Course Title: **Design and Analysis of Algorithms**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory:3** **Practical:0**

4. Relative Weightage: **CWS:15** **PRS:0** **MTE:35** **ETE:50** **PRE:0**

5. Credits**:3** 6. Semester: **Autumn** 7. Subject Area: **DCC**

8. Pre-requisite: **Nil**

9. Objective: To introduce fundamentals of algorithms, their analysis and complexity issues.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Notion of algorithm, pseudo code conventions, Performance analysis, Time and space complexities, Asymptotic notation, Big oh notation, omega notation, theta notation, Average and worst case analysis, Probabilistic analysis, Amortized analysis. | **5** |
| **2.** | Recurrence relations, Divide and conquer relations, Solving of recurrences by iteration method and substitution method, Master theorem, Binary search algorithm, Merger sort, Quick sort, Strassen's matrix multiplication method. | **9** |
| **3.** | Greedy strategy, Huffman coding algorithm, Data structures of disjoint sets, Complexity analysis of Depth first search, Breadth first search, Prim's algorithm, Kruskal's algorithm, Dijkstra's and Bellman-Ford algorithms, Knapsack problem, Warshall's and Floyd's algorithms. | **12** |
| **4.** | Introduction to dynamic programming, Principle of optimality, Optimal binary search trees, Matrix-chain multiplication, Longest common subsequence. | **7** |
| **5.** | String matching, The naive string matching algorithm, The Rabin-Karp algorithm | **3** |
| **6.** | Introduction to computability, Reducibility, Polynomial-time verification, NP-completeness, NP-complete problems. | **6** |
| | **Total** | **42** |

11. Suggested References/Books:

| S.No. | Name of Authors / Books / Publishers | Year of Publication/ Reprint |
|---|---|---|
| 1. | Cormen T. H., Leiserson C. E., Rivest R. L. and Stein C., "Introduction to Algorithms", Prentice Hall India, (3rd Edition) | 2004 |
| 2. | Aho A. V., Hopcroft J. E. and Ullman J. D., "The Design and Analysis of Computer Algorithms", Pearson Education | 2002 |
| 3. | Horowitz E., Sahni S. and Rajasekaran S., "Fundamentals of Computer Algorithms", Orient Longman | 2006 |
| 4. | Kleinberg J. and Tardos E., "Algorithm Design", Pearson Education | 2008 |
| 5. | Levitin A., "Introduction to the Design and Analysis of Algorithm", (2nd edition) Pearson Education | 2003 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MAN-208** Course Title: **Number Theory**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory:3** **Practical :0**

4. Relative Weightage**: CWS:25** **PRS:0** **MTE:25** **ETE:50** **PRE:0**

5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**: Nil**

9. Objective: To give an introduction of basic concepts of Number Theory.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Divisibility, Euclidean algorithm, Linear Diophantine equations, Prime numbers, Fundamental theorem of arithmetic, Prime number theorem (statement only). | **7** |
| **2.** | Congruences, solutions of linear congruences, Chinese Remainder Theorem, Euler's totient function, Euler-Fermat theorem, Wilson's theorem, non-linear congruences, Hensel's lemma, primitive roots and power residues. | **12** |
| **3.** | Quadratic residues, quadratic reciprocity, the Jacobi symbols. | **7** |
| **4.** | The greatest integer function, Arithmetic functions, Mobius function and Mobius inversion formula. | **6** |
| **5.** | Finite continued fractions, infinite continued fractions, approximation to irrational numbers. | **6** |
| **6.** | Introduction to cryptography, public key cryptography, RSA. | **4** |
| | Total | **42** |

11. Suggested Books:

| S.No. | Name of Authors / Books / Publishers | Year of Publication/ Reprint |
|---|---|---|
| 1. | Niven I., Zuckerman H. S., and Montgomery H. L., "An Introduction to the Theory of Numbers", John Wiley & Sons ($5^{th}$ Ed.) | 1991 |
| 2. | Hardy, G., H. and Wright, E. M, "An Introduction to the Theory of Numbers ", Oxford University Press ($6^{th}$ Ed.) | 2008 |
| 3. | Burton D., M., "Elementary Number Theory", McGraw Hill ($7^{th}$ Ed.) | 2010 |
| 4. | Andrews G. E., “Number Theory”, Dover Publications | 1994 |
| 5. | Koblitz N., A Course in Number Theory and Cryptography, Springer ($2^{nd}$ Ed.) | 1994 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MAN-301** Course Title: **Abstract Algebra I**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory:3** **Practical:0**

4. Relative Weightage: **CWS:25** **PRS:0** **MTE:25** **ETE:50** **PRE:0**

5. Credits:4 6. Semester: **Autumn** 7. Subject Area: **DCC**

8. Pre-requisite: **Nil**

9. Objective: To introduce the basic concepts of abstract algebra.

10. Detail of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Group theory: Definition and some examples of groups, some preliminary lemmas, subgroups, a counting principle, normal subgroups and Quotient groups. | **12** |
| **2.** | Homomorphisms, automorphisms, Cayley's theorem, permutation groups, Sylow's theorems. | **11** |
| **3.** | Ring theory: Definition and examples of Rings, some special classes of Rings, homomorphisms, Ideal and Quotient rings, Maximal Ideal, Integral domain, Principal Ideal domain, unique factorization domain. | **11** |
| **4.** | Definition of field and some examples, the field of Quotients of an Integral domain, Euclidean rings, polynomial rings. | **8** |
| | **Total** | **42** |

11. Suggested Books:

| S.No. | Name of Authors / Books / Publishers | Year of Publication/ Reprint |
|---|---|---|
| 1. | Herstein, I. N., "Topics in Algebra", 2nd Ed., John Wiley & Sons. | 2004 |
| 2. | Fraleigh, J. B., "A First Course in Abstract Algebra", 7th Ed., Pearson Education | 2003 |
| 3. | Dummit, D. S. and Foote, R. M., "Abstract Algebra", 3rd Ed., John Wiley & Sons. | 2004 |
| 4. | Artin M., “Algebra”, 2nd Ed., Prentice Hall India | 2011 |
| 5. | Gallian J. A., “Contemporary Abstract Algebra”, 8th Ed., Cengage Learning | 2013 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MAN-302** Course Title: **Mathematical Modeling and Simulation**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory:3** **Practical:0**

4. Relative Weightage**: CWS:25** **PRS:0** **MTE:25** **ETE:50** **PRE:0**

5. Credits**:4** 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**: Nil**

9. Objective: To develop basic understanding of modeling and simulation techniques.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | What is Mathematical Modeling? History of Mathematical Modeling, latest development in Mathematical Modeling, Merits and Demerits of Mathematical Modeling. | **4** |
| **2.** | Introduction to difference equations, Non-linear Difference equations, Steady state solution and linear stability analysis.<br>Introduction to Discrete Models, Linear Models, Growth models, Decay models, Newton's Law of Cooling, Bank Account Problem and mortgage problem, Drug Delivery Problem, Harrod Model of Economic growth, War Model, Lake pollution model, Alcohol in the bloodstream model, Arm Race models, Linear Prey-Predator models, Density dependent growth models with harvesting, Numerical solution of the models and its graphical representation using EXCEL. | **14** |
| **3.** | Introduction to Continuous Models, Carbon Dating, Drug Distribution in the Body, Growth and decay of current in a L-R Circuit, Horizontal Oscillations, Vertical Oscillations, Damped Force Oscillation, Dynamics of Rowing, Combat Models, Mathematical Model of Influenza Infection (within host), Epidemic Models (SI, SIR, SIRS, SIC), Spreading of rumour model, Steady State solutions, Linearization and Local Stability Analysis, logistic and gomperzian growth, prey-predator model, Competition models, Numerical solution of the models and its graphical representation using EXCEL. | **14** |
| **4.** | Fluid flow through a porous medium, heat flow through a small thin rod (one dimensional), Wave equation, Vibrating string, Traffic flow, Theory of Car-following, Crime Model, Linear stability Analysis: one and two species models with diffusion, Conditions for diffusive instability with examples. | **10** |
| | **Total** | **42** |

11. Suggested Books:

| S. No. | Name of Books / Authors/ Publishers | Year of Publication/ Reprint |
|---|---|---|
| 1. | Albright, B., "Mathematical Modeling with Excel", Jones and Bartlett Publishers. | 2010 |
| 2. | Marotto, F. R., "Introduction to Mathematical Modeling using Discrete Dynamical Systems", Thomson Brooks/Cole. | 2006 |
| 3. | Kapur, J. N., "Mathematical Modeling", New Age International | 2005 |
| 4. | Barnes, B. and Fulford, G. R., "Mathematical Modelling with Case Studies", CRC Press, Taylor and Francis Group. | 2009 |
| 5. | Edsberg, L., "Introduction to Computation and Modeling for Differential Equations", John Wiley and Sons. | 2008 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MAN-303** Course Title: **Mathematical Statistics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical:0**

4. Relative Weightage**: CWS:25** **PRS:0** **MTE:25** **ETE:50** **PRE:0**

5. Credits**:4** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**:** : **Nil**

9. Objective: To impart the knowledge of basics of mathematical statistics.

10. Details of Course:

| S.No. | Contents | Contact Hours |
|---|---|---|
| **1** | Concept of probability, random variable and distribution function: discrete and continuous distributions, moments and moment generating functions. | **6** |
| **2** | Some discrete distributions: Binomial, Poisson, Negative binomial, Geometric, Hypergeometric. | **6** |
| **3** | Some continuous distributions: Uniform, Exponential, Gamma, Normal, Lognormal, Beta, Weibull, Cauchy, Pareto. | **8** |
| **4** | Bivariate random variables: joint, marginal, conditional distribution. Statistical independence, product moment, correlation, regression, transformation of random variables, distribution of distribution function. | **10** |
| **5** | Law of large numbers, central limit theorem. | **04** |
| **6** | Simple random sampling with replacement and without replacement, mean and variance of sample mean and variance, parameter and statistics, order statistics and distribution of order statictics, fundamental sampling distribution from normal population viz. $\chi^2$, t, f and Z (central) | **08** |
| | **TOTAL** | **42** |

11. Suggested Books:

| S.No. | Name of Books / Authors/ Publishers | Year of Publication/Reprint |
|---|---|---|
| 1. | Miller, I. and Miller, M., "Freund's Mathematical Statistics with Applications", Prentice Hall PTR ,7th Ed. | 2006 |
| 2. | Hogg, R. V. and Craig, A., "Introduction to Mathematical Statistics", Pearson Education, 6th Ed. | 2006 |
| 3. | Rohatgi, V. K. and Md. Ehsanes Saleh, A. K., "An Introduction to Probability and Statistics", John Wiley and Sons, 2nd edition. | 2000 |
| 4. | Papoulis, A., Pillai, S.U., Probability, "Random Variables and Stochastic Processes", Tata McGraw-Hill, 4th Ed. | 2002 |
| 5. | Bhatt B.R., "Modern Probability Theory", New Age International Ltd, 3rd Ed. | 1999 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MAN-304** Course Title: **Theory of Computation**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory:3** **Practical:0**

4. Relative Weightage**: CWS:25** **PRS:0** **MTE:25** **ETE:50** **PRE:0**

5. Credits**:4** 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**: Nil**

9. Objective: To introduce the theory of automata, languages and grammars.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Basic definitions, deterministic and non-deterministic finite automata, regular languages, equivalence of deterministic and non-deterministic finite automata, state equivalence and minimization, regular expressions, equivalence of regular expressions and finite automata | **9** |
| **2.** | Properties of regular languages, Pumping lemma, Grammars, Types of grammars | **6** |
| **3.** | Context-free languages, parse tree, simplifications of context-free grammars, Chomsky normal form, Greibach normal form | **6** |
| **4.** | Pushdown automata, deterministic and non-deterministic pushdown automata, equivalence of pushdown automata with context free languages | **6** |
| **5.** | Properties of context-free languages, Pumping lemma for context-free languages | **4** |
| **6.** | Turing machines, computable languages and functions, modifications of Turing machines | **6** |
| **7.** | Computability and decidability, undecidable problems, Halting problem, Complexity classes: P, NP and NP complete | **5** |
| | **Total** | **42** |

11. Suggested Books**:**

| S.No. | Name of Authors / Books / Publishers | Year of Publication/ Reprint |
|---|---|---|
| 1. | Hopcroft J. E., Motwani R. and Ullman J. D., “Introduction to automata Theory, languages and Computation”, Pearson Education (3rd Ed.) | 2008 |
| 2. | Sipser M., “Introduction to the Theory of Computation”, Course Technology (2nd Ed.) | 2012 |
| 3. | Lewis H. R. and Papadimitriou C. H., "Elements of the Theory of Computation", Prentice Hall (2nd Ed.) | 1998 |
| 4. | Linz P., “An Introduction to Formal Languages and Automata”, Jones and Bartlett (5th Ed.) | 2012 |
| 5. | Kozen D., "Automata and Computability", Springer | 1997 |
| 6. | Cohen D. I. A., “Introduction to Computer Theory”, John Wiley & Sons (2nd Ed.) | 1996 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MAN-305** Course Title: **Linear Programming**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory:3** **Practical:0**

4. Relative Weightage**: CWS:25** **PRS:0** **MTE:25** **ETE:50** **PRE:0**

5. Credits**: 4** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**: Nil**

9. Objective: To acquaint students with the basic techniques of linear programming.

10. Details of Course:

| S.No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Different Types of OR Models | **2** |
| **2.** | Convex Sets, Graphical Method, Simplex Method, Big – M Method, Two Phase Method, Revised Simplex Method | **11** |
| **3.** | Duality Theory, Dual Simplex Method, Sensitivity Analysis, Parametric Linear Programming | **9** |
| **4.** | Cutting Plane and Branch and Bound Techniques for all Integer and Mixed Integer Programming Problems, | **5** |
| **5.** | Transportation Problems and Assignment Problems | **5** |
| **6.** | Graphical Method and Linear Programming Method for Rectangular Games, Saddle point, Notion of Dominance | **5** |
| **7.** | CPM/ PERT | **5** |
| | TOTAL | **42** |

11. Suggested Books:

| S.No. | Name of Authors / Books / Publishers | Year of Publication/ Reprint |
|---|---|---|
| 1 | Taha, H.A., "Operations Research: An Introduction", MacMillan Pub Co., NY, 9th Ed. (Reprint). | 2013 |
| 2 | Mohan, C. and Deep, K., "Optimization Techniques", New Age India Pvt. Ltd, New Delhi. | 2009 |
| 3 | Mittal, K.V. and Mohan, C., "Optimization Methods in System Analysis and Operations Research", New Age India Pvt. Ltd, New Delhi. | 1996 |
| 4 | Ravindran, A., Phillips, D.T. and Solberg, J.J., "Operations Research: Principles and Practice", John Wiley and Sons, NY, 2nd Ed. (Reprint). | 2012 |
| 5 | Pant, J.C., "Introduction to Optimization/Operations Research", Jain Brothers, New Delhi, 2nd Ed. | 2012 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MAN-501** Course Title: **Theory of Ordinary Differential Equations**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory:3** **Practical:0**

4. Relative Weightage**: CWS:15** **PRS:0** **MTE:35** **ETE:50** **PRE:0**

5. Credits**:3** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**: Nil**

9. Objective: To introduce the theoretical concepts of ordinary differential equations.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Existence, uniqueness and continuation of solutions of a differential equation and system of differential equations. Differential and integral inequalities. Fixed point methods. | **9** |
| **2.** | Linear systems, properties of homogeneous and non-homogeneous systems, behaviour of solutions of $n^{th}$ order linear homogeneous equations. | **7** |
| **3.** | Review of power series, Power series solution of second order homogeneous equations, ordinary points, regular singular points, solution of Gauss hypergeometric equations, Hermite and Chebyshev polynomials. | **8** |
| **4.** | Boundary value problems for second order differential equations,Green's function and its applications. Eigen value problems, self adjoint form, Sturm –Liouvile problem and its applications. | **8** |
| **6.** | Autonomous systems, phase plane and its phenomenon, critical points and stability for linear and non linear systems, Liapunov's direct method, periodic solutions, limit cycle, the Poincare-Bendixson theorem. | **10** |
| | **Total** | **42** |

11. Suggested Books:

| S.No. | Name of Authors / Books / Publishers | Year of Publication/ Reprint |
|---|---|---|
| 1. | Braun, M. "Differential Equations and Their Applications", 4th Ed., Springer | 2011 |
| 2. | Brauer, F. and Nohel, J.A., "The Qualitative Theory of Ordinary Differential Equations", Dover Publications | 1989 |
| 3. | Coddington E.A., "Ordinary Differential Equations", Tata McGraw Hill | 2002 |
| 4. | Deo, S.G., Lakshmikantham, V., and Raghvendra, V.,"Text Book of Ordinary Differential Equations", 2nd Ed., Tata McGraw Hill | 2010 |
| 5. | Simmons G.F., "Ordinary Differential Equations with Applications", Tata McGraw Hill | 2003 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MAN-502** Course Title: **Advanced Numerical Analysis**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory:3** **Practical:0**

4. Relative Weightage**: CWS:25** **PRS:0** **MTE:25** **ETE:50** **PRE:0**

5. Credits**:4** 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**:** Basic course in Numerical methods

9. Objective: To impart knowledge of numerical analysis in solving differential equations.

10. Details of Course:

| S. No. | Contetns | Contact Hours |
|---|---|---|
| **1.** | **Computations of Eigen Values of a Matrix:** Power method for dominant, sub-dominant and smallest eigen-values, Method of inflation, Jacobi, Givens and Householder methods for symmetric matrices, LR and QR methods. | **10** |
| **2.** | **Initial Value Problems**: Multistep methods, their error analysis and stability analysis | **6** |
| **3.** | **Inverse interpolation:** Their developments and applications | **4** |
| **4.** | **Finite Difference**: Review of finite difference operators, finite difference methods. | **2** |
| **5.** | **Elliptic PDE**: Five point formulae for Laplacian, replacement for Dirichlet and Neumann's boundary conditions, curved boundaries, solution on a rectangular domain, block tri-diagonal form and its solution using method of Hockney, condition of convergence | **5** |
| **6.** | **Parabolic PDE**: Concept of compatibility, convergence and stability, Explicit, full implicit, Crank-Nicholson, du-Fort and Frankel scheme, ADI methods to solve two-dimensional equations with error analysis. | **5** |
| **7.** | **Hyperbolic PDE**: Solution of hyperbolic equations using FD, and Method of characteristics ,Limitations and Error analysis | **5** |
| **8.** | **Weighted residual methods**: Collocation, least squares, Galerkins, Rayleigh-Ritz methods and their compatibility | **5** |
| | **TOTAL** | **42** |

11. Suggested Books:

| S.No. | Name of Authors / Books / Publishers | Year of Publication/ Reprint |
|---|---|---|
| 1. | Gerald, C. F. and Wheatly P. O., "Applied Numerical Analysis", 6th Ed., Addison-Wesley Publishing | 2002 |
| 2. | Smith, G. D., " Numerical Solution of Partial Differential Equations", Oxford University Press. | 2001 |
| 3. | Jain, M. K., " Numerical Solution of Differential Equations", John Wiley. | 1991 |
| 4. | Fausett, L. V., "Applied Numerical Analysis", Prentice Hall, 2nd Ed. | 2007 |
| 5. | Froberg, C. E., "Introduction to Numerical Analysis", 2nd Ed., Addison Wesley. | 2004 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MAN-503** Course Title: **Real Analysis-II**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory:3** **Practical:0**

4. Relative Weightage**: CWS:15** **PRS:0** **MTE:35** **ETE:50** **PRE:0**

5. Credits**:3** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**:** **Nil**

9. Objective: To introduce some advanced topics in theory of real functions and metric spaces.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Functions of several variables, invertible functions, Jacobian of a transformation, Inverse mapping theorem, Implicit function theorem | **6** |
| **2.** | Riemann Stieltjes integrals, Existence and properties of the integrals, Fundamental theorem of calculus, first and second mean value theorems. | **12** |
| **3.** | Introduction to the properties of general measure and measurable spaces, Borel Algebras, complete measure. | **5** |
| **4.** | Lebesgue outer measure and measure on the real line, measurable sets and their properties, translation invariance and completeness of Lebesgue measure, Lebesgue integral of a simple function, comparison of Lebesgue and Riemann integrals | **12** |
| **5.** | Review of complete metric spaces, compact metric spaces, compactness and uniform continuity and connected metric spaces. | **7** |
| | | **42** |

11. Suggested Books:

| S.No. | Name of Authors/ Books/Publishers | Year of Publication/Reprint |
|---|---|---|
| 1. | Aliprantis, C.D.and Burkinshaw, W., "Principles of Real Analysis", Elsevier. | 2011 |
| 2. | Apostol, T.M., "Mathematical Analysis", Narosa Publishing House. | 2002 |
| 3. | Barra, G.D., "Measure theory and Integration", Woodhead Publishing. | 2003 |
| 4. | Lang, S., "Real and Functional Analysis", Springer-Verlag. | 1993 |
| 5. | Rana, I.K., "An Introduction to Measure and Integration", Narosa Publishing House. | 2007 |
| 6. | Rudin, W., "Principles of Mathematical Analysis", McGraw-Hill Book Company. | 1976 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTR: **Department of Mathematics**

1. Subject Code: **MAN-504** Course Title: **Abstract Algebra II**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory:3** **Practical:0**

4. Relative Weightage**: CWS:15** **PRS:0** **MTE:35** **ETE:50** **PRE:0**

5. Credits**: 3** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**: Nil**

9. Objective: To provide an exposure of the advanced topics in rings, modules and Field theory.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Basic concepts of rings, Homomorphism and ideals, Euclidean domains, Principal ideal domains, Unique factorization domains. | **6** |
| **2.** | Introduction to modules, Submodules, Quotient modules, Module homomorphism, Simple modules, Cyclic modules, Direct sum of modules, Free modules, Finitely generated modules over principal ideal domains, Fundamental theorem of Abelian groups. | **10** |
| **3.** | Modules with chain conditions, Noetherian rings and modules, Hilbert basis theorem, Primary decomposition of ideals in Noetherian rings. | **10** |
| **4.** | Field Extensions, Algebraic extensions, Splitting fields and algebraic closures, Normal and separable extensions. | **6** |
| **5.** | Introduction to Galois theory, Fundamental theorem of Galois theory. | **6** |
| **6.** | Finite fields. | **4** |
| | **Total** | **42** |

11. Suggested References/Books:

| S.No. | Name of Authors / Books / Publishers | Year of Publication/ Reprint |
|---|---|---|
| 1. | Dummit, D. S. and Foote, R. M., "Abstract Algebra", John Wiley & Sons (3rd Edition) | 2003 |
| 2. | Bhattacharya, P. B., Jain, S. K. and Nagpaul, S. R., "Basic Abstract Algebra", Cambridge University Press (2nd Ed.) | 1995 |
| 3. | Hungerford, T. W., "Algebra", Springer | 1980 |
| 4. | Lang S., "Algebra", Springer (3rd Ed.) | 2005 |
| 5. | Jacobson N., "Basic Algebra Vol. 1", Dover Publications (2nd Ed.) | 2009 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MAN-505** Course Title: **Topology**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory:3** **Practical: 0**

4. Relative Weightage**: CWS:15** **PRS:0** **MTE:35** **ETE:50** **PRE:0**

5. Credits**:3** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**:** **Nil**

9. Objective: To impart the knowledge of the basic concepts of Topology.

10. Details of Course:

| S.No. | Contents | Contact Hours |
|---|---|---|
| **1** | **Introduction:** Finite, countable, uncountable sets, functions, relations, Axiom of choice, Zorn's Lemma | **2** |
| **2** | **Topological Spaces and Continuous functions:** Open sets, closed sets, basis for a topology, Sub basis, $T_1$ and $T_2$ Spaces, Order topology, product topology, subspace topology, limit point, continuous function, general product topology, metric space and its Topology, quotient topology | **14** |
| **3** | **Connectedness an d C ompactness:** Connected spaces, connected subspaces, Local connectedness, compact subspace, limit point compactness, Local compactness | **12** |
| **4** | **Countability an d S eparation axi om:** Countability axioms, separation axioms. Regular and Normal Spaces, Urysohn's Lemma, Urysohn metrization Theorem, Tietze Extension Theorem, Tychonoff Theorem | **14** |
| | **TOTAL** | **42** |

11. Suggested Books:

| S.No. | Name of Authors / Books / Publishers | Year of Publication/ Reprint |
|---|---|---|
| 1. | Munkres, J.R., "Topology", 2nd edition, PHI | 2010 |
| 2. | Mansfield, M.J., "Introduction to Topology", East-West student Edition | 1973 |
| 3. | Simmons, G.F., "Introduction to Topology & Modern Analysis", Krieger Publishing Company. | 2003 |
| 4. | Mendelson, B., "Introduction to Topology," 3rd Ed., Dover Publications | 1988 |
| 5. | Gamelin, T.W. and Greene, R.E., "Introduction to Topology", 2nd Ed., Dover Publications | 1999 |
| 6. | Min, Y., "Introduction to Topology: Theory & Applications", Higher Education Press | 2010 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MAN-506** Course Title: **Nonlinear Programming**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory :3** **Practical:0**

4. Relative Weightage**: CWS:25** **PRS:0** **MTE:25** **ETE:50** **PRE:0**

5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**: Nil**

9. Objective: To introduce the basic techniques of nonlinear programming.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1** | Convex Functions, Karash Kuhn-Tucker Theory, Convex Quadratic Programming, Wolfe's, Beale and Pivot Complementary Algorithm, Separable Programming. | **12** |
| **2** | Geometric Programming: Problems with positive co-efficient up-to one degree of difficulty, Generalized method for problems with positive and negative coefficients. | **6** |
| **3** | Dynamic Programming: Discrete and continuous Dynamic Programming, Simple illustrations. | **6** |
| **4** | Search Techniques: Direct Search and Gradient Methods, Unimodal Functions, Fibonacci Method, Golden Section Method, Method of Steepest Descent, Newton Raphson Method, Hookes and Jeeves Method, Conjugate Gradient Methods. | **11** |
| **5** | Constrained optimization: Penalty function approach, Barrier Function Approach. | **2** |
| **6** | Multi-objective and Goal Programming. | **5** |
| | **TOTAL** | **42** |

11. Suggested Books:

| S.No. | Name of Books/ Authors/ Publishers | Year of Publication |
|---|---|---|
| **1** | Mohan C., Deep, K., "Optimization Techniques", New Age India Pvt. Ltd, New Delhi. | **2009** |
| **2** | Mittal K. V., Mohan, C., "Optimization Methods in System Analysis and Operations Research", New Age India Pvt. Ltd, New Delhi. | **1996** |
| **3** | Taha H. A., "Operations Research: An Introduction", MacMillan Pub Co., NY, 9th Edition (Reprint). | **2013** |
| **4** | Ravindran A, Phillips D. T., Solberg J. J., "Operations Research: Principles and Practice", John Wiley and Sons, NY, Second Edition (Reprint). | **2012** |
| **5** | Pant J. C., "Introduction to Optimization/ Operations Research", Jain Brothers, New Delhi, Second Edition. | **2012** |
| **6** | Bazaraa, M., Sherali, H. D. and Shetty, C. M., "Nonlinear Programming: Theory and Algorithms", Wiley-Interscience; 3rd Ed. | **2006** |
| **7** | Himmelblau, D. M., "Applied Nonlinear Prograaming", Mcgraw-Hill | **1972** |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MAN-507** Course Title: **Statistical Inference**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory:3** **Practical:0**

4. Relative Weightage**: CWS:15** **PRS:0** **MTE:35** **ETE:50** **PRE:0**

5. Credits**:3** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**:** : **Nil**

9. Objective: To introduce the concepts of statistical inference.

10. Details of Course:

| S.No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Principle of Data Reduction: Sufficiency principle, Factorization criterion, minimal sufficiency, Completeness and bounded completeness, Likelihood principle, Equivariance principle. | **08** |
| **2.** | Theory of Estimation: Basic concepts of estimation, Point estimation, , methods of estimation; method of moments, method of maximum likelihood; Unbiasedness, Minimum variance estimation, Cramer – Rao bound and its generalization, Rao Blackwell theorem, Existence of UMVUE estimators. Interval Estimation, Some results for normal population case. | **12** |
| **3.** | Testing of Hypothesis: Null and alternative hypothesis, Type I and II errors error probability and power function, Method of finding tests, Neyman – Pearson lemma, Uniformly most powerful tests, Likelihood ratio principle, Likelihood ratio test, Sequential probability ratio test, Some results based on normal population. | **18** |
| **4.** | Analysis of Variance: one way classification; simple linear regression analysis with normal distribution. | **04** |
| | **TOTAL** | **42** |

11. Suggested Books:

| S.No. | Name of Authors / Books / Publishers | Year of Publication/ Reprint |
|---|---|---|
| 1. | Miller, I. and Miller, M.,"Freund's Mathematical Statistics with Applications", Prentice Hall PTR, 7th edition | 2006 |
| 2. | Lehman, E.L., "Testing of Statistical Hypothesis", Wiley Eastern Ltd | 1959 |
| 3. | G. Casella, R. L. Berger, "Statistical Inference", Duxbury Press | 2002 |
| 4. | Lehman, E.L., "Point Estimation", John Wiley & sons | 1984 |
| 5. | Rohatgi, V.K., "Statistical Inference", Dover Publications | 2011 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MAN-508** Course Title: **Theory of Partial Differential Equations**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory:3** **Practical:0**

4. Relative Weightage**: CWS:15** **PRS:0** **MTE: 35** **ETE:50** **PRE:0**

5. Credits**:3** 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**:** **Nil**

9. Objective: To provide theoretical concepts of partial differential equations.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Introduction: Surfaces and curves. Simultaneous differential equations of the first order and first degree. Integral curves of vector fields. Methods of solution of $dx/P = dy/Q = dz/R$. Orthogonal Trajectories of a system of curves on a surface. Pfaffian differential forms and equations. Solution of Pfaffian differential equations in three variables. | **6** |
| **2.** | First Order PDE: Partial differential equations, Origins and classification of first order PDE, Initial value problem for quasi-linear first order equations: Existence and uniqueness of solution, Non-existence and non-uniqueness of solutions. Surfaces orthogonal to a given system of surfaces. Nonlinear PDE of first order, Cauchy method of Characteristics, Compatible systems of first order equations, Charpit's method, Solutions satisfying given conditions. Jacobi's method. | **8** |
| **3.** | Second Order PDE: The origin of second order PDE. Equations with variable coefficients, Classification and canonical forms of second order equations in two variables. Classification of second order equations in n variables. Characteristic curves of second order equations in two variables. Importance of characteristic curves. | **5** |
| **4.** | Review of Integral Transform and Fourier series. | **2** |
| **5.** | Elliptic Equations: Laplace equation in Cartesian, polar, spherical and cylindrical coordinates and its solution by Fourier series method, Poisson equation in 2D. Green's function for Laplace equation, method of Images, eigenfunction method for finding Green's function. | **9** |
| **6.** | Hyperbolic Equation: One and two dimensional wave equation, solution by method of characteristics and Fourier series method. | **7** |

| | | |
|---|---|---|
| **7.** | Parabolic Equations: solution of homogeneous and non-homogeneous diffusion equation (1D). Duhamel's principle. | **5** |
| | Total | **42** |

11. Suggested Books:

| **S.No.** | **Name of Authors / Books / Publishers** | **Year of Publication/ Reprint** |
|---|---|---|
| 1. | Zachmanoglou, E.C., Thoe, D.W., "Introduction to Partial Differential Equattions with Applications", Dover Publications. | 1986 |
| 2. | Sneddon, I. N., "Elements of Partial Differential Equations", McGraw-Hill Book Company. | 1988 |
| 3. | Amarnath, T., "An Elementary Course in Partial Differential Equations", Narosa Publishing House (II Edition). | 2012 |
| 4. | Rao, K. S., "Introduction to Partial Differential Equations", PHI Learning Pvt. Ltd. ($2^{nd}$ Edition). | 2012 |
| 5. | Lawrence C. Evans, "Partial Differential Equations", American Mathematical Society | 2010 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MAN-510** Course Title: **Complex Analysis-II**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory:3** **Practical:0**

4. Relative Weightage**: CWS:15** **PRS:0** **MTE:35** **ETE:50** **PRE:0**

5. Credits**: 3** 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**: Nil**

9. Objective: To provide advance topics in functions of one complex variable.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | **Analytic F unctions**: Zeroes of analytic functions, Jensen's theorem, meromorphic functions, their zeroes and poles, Poisson-Jensen's formula. Revisit to Argument principle, Rouche's theorem. | **5** |
| **2.** | **Entire F unctions**: Order and genus of entire functions, Hadamard's factorization theorem, coefficient formula for the order, the derived function, exceptional values, Borel's theorem, Little Picard and Great Picard theorem. | **6** |
| **3.** | **Harmonic F unctions**: Harmonic functions in the disc, Mean Value Property, Maximum and Minimum Principle, Harnack's inequality, Harnack's theorem, The Dirichlet Problem. | **6** |
| **4.** | **Analytic C ontinuation**: Definition and uniqueness of analytic continuation, standard method of analytic continuation using power series, the principle<br>of reflection, Hadamard multiplication theorem, Monodromy theorem, Riemann Surfaces,. Homology and homotopy versions of Cauchy's theorem, simply connected regions. | **9** |
| **5.** | **Spaces of Analytic functions** Compactness and Convergence, Hurwitz Theorem, Weirstrass factorization theorem, Runge's theorem, Mittag Leffler theorem, Normal families, Equiboundedness, Arzela's theorem | **9** |
| **6.** | **Function t heory**: Subordination, Riemann mapping theorem, Univalent functions. Gamma function, Riemann zeta function, Riemann hypothesis. | **7** |
| | **Total** | **42** |

11. Suggested Books:

| S.No. | Name of Authors/ Books/Publishers | Year of Publication/Reprint |
|---|---|---|
| **1.** | Ahlfors, L. V., "Complex Analysis", McGraw Hill | **1988** |
| **2.** | Conway, J. B., "Functions of one complex Variables I", Narosa Publishing House. | **2000** |
| **3.** | Gamelin, T. W., "Complex Analysis", Springer-Verlag | **2001** |
| **4.** | Greene, R., and Krantz, S. G., "Function Theory of One Complex Variable", GSM, Vol. 40, American Mathematical Society, ($3^{rd}$ Ed.) | **2006** |
| **5.** | Lang, S., "Complex Analysis", Springer – Verlag. | **2003** |
| **6.** | Narasimhan, R. and Nievergelt, Y., "Complex Analysis in One Variable", Birkhauser ($2^{nd}$ Ed.) | **2001** |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mathematics**
1. Subject Code: **MAN-601** Course Title: **Fluid Dynamics**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory:3** **Practical:0**

4. Relative Weightage**: CWS:15** **PRS:0** **MTE:35** **ETE:50** **PRE:0**

5. Credits**:3** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**: Nil**

9. Objective: To introduce basic concepts of fluid dynamics and boundary layer theory

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Lagrangian and Eulerian descriptions, Continuity of mass flow, circulation, rotational and irrotational flows, boundary surface, streamlines, path lines, streak lines, vorticity | **6** |
| **2.** | General equations of motion: inviscid case, Bernoulli's theorem, compressible and incompressible flows, Kelvin's theorem, constancy of circulation | **4** |
| **3.** | Stream function, Complex-potential, source, sink and doublets, circle theorem, method of images, Theorem of Blasius, Strokes stream function, Motion of a sphere. | **5** |
| **4.** | Helmholtz's vorticity equation, vortex filaments, vortex pair. | **2** |
| **5.** | Navier-Stokes equations, dissipation of energy, diffusion of vorticity, Steady flow between two infinite parallel plates through a circular pipe (Hagen-Poiseuille flow), Flow between two co-axial cylinders, Energy equation, Dynamical similarity | **9** |
| **6.** | Dimensional analysis, large Reynold's numbers; Laminar boundary layer equations, Similar solutions; Flow past a flat plate, Momentum integral equations, Solution by Karman-Pohlhausen methods, impulsive flow Reyleigh problem, dynamical similarity Thermal boundary layer equation for incompressible flow; Temperature distribution in Coutte flow and in flow past a flat plate. | **5** |
| **7.** | Mathematical formulation of the stability problem of incompressible flow, Stability of flows under different cases, Prandtl's momentum transfer theory. | **7** |
| **8** | Introduction to Complex fluids. | **4** |
| | **TOTAL** | **42** |

11. Suggested Books:

| S.No. | Title/Authors/Publishers | Year of Publication/ Reprint |
|---|---|---|
| 1. | Batechelor, G.K., “An Introduction to Fluid Dynamics”, Cambridge Press. | 2002 |
| 2. | Schliting, H. , Gersten K., “Boundary Layer Theory”, Springer, 8$^{th}$ edition. | 2004 |
| 3. | Rosenhead, “Laminar Boundary Layers”, Dover Publications | 1963 |
| 4. | Drazin, P.G., Reid W. H., “Hydrodynamic Stability”, Cambridge Press | 2004 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MAN-603** Course Title: **Tensors and Differential Geometry**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory:3** **Practical :0**

4. Relative Weightage**: CWS:15** **PRS:0** **MTE:35** **ETE:50** **PRE:0**

5. Credits**:3** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**: Nil**

**9. Objective:** To provide the basics geometric concepts curves, surfaces and tensors.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| 1. | **Theory of S pace C urves:** Space curves, Planer curves, Curvature, Torsion and Serret-Frenet formulae. Osculating circles, Osculating circles and spheres. Existence of space curves. Evolutes and involutes of curves. | **8** |
| 2. | **Theory of S urfaces:** Parametric curves on surfaces. Direction coefficients. First and second Fundamental forms. Principal and Gaussian curvatures. Lines of curvature, Euler's theorem. Rodrigue's formula, Conjugate and Asymptotic lines. | **9** |
| 3. | **Developables:** Developable associated with space curves and curves on surfaces, Minimal surfaces. | **6** |
| 4. | **Geodesics:** Canonical geodesic equations. Nature of geodesics on a surface of revolution. Clairaut's theorem. Normal property of geodesics. Torsion of a geodesic. Geodesic curvature. Gauss-Bonnet theorem. Surfaces of constant curvature. Conformal mapping. Geodesic mapping. Tissot's theorem. | **9** |
| 5. | **Tensors:** Summation convention and indicial notation, Coordinate transformation and Jacobian, Contra-variant and Covariant vectors, Tensors of different type, Algebra of tensors and contraction, Metric tensor and 3-index Christoffel symbols, Parallel propagation of vectors, Covariant and intrinsic derivatives, Curvature tensor and its properties, Curl, Divergence and Laplacian operators in tensor form, Physical components. | **10** |
| | **Total** | **42** |

11. Suggested Books:

| S.No. | Title/Authors/Publishers | Year of Publication/ Reprint |
|---|---|---|
| 1. | Willmore, T. J., "An Introduction to Differential Geometry", Dover publications. | 2012 |
| 2. | O'Neill B., Elementary Differential Geometry, Academic press, 2nd Ed. | 2006 |
| 3. | Weatherburn, C.E. Differential Geometry of Three Dimensions, Cambridge University Press (digital pub) | 2003 |
| 4. | Struik, D., J., "Lectures on Classical Differential Geometry", Dover Publications. | 1988 |
| 5. | Lang, S., Fundamentals of Differential Geometry, Springer. | 1999 |
| 6. | Spain, B., "Tensor Calculus: A concise Course", Dover Publications | 2003 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

**NAME OF DEPTT./CENTRE: Department of Mathematics**

1. Subject Code: **MAN-605** Course Title: **Functional Analysis**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weightage**: CWS: 15** **PRS: 0** **MTE: 35** **ETE: 50** **PRE: 0**

5. Credits:3 6. Semester: **Autumn** 7. Subject Area: **DCC**

8. Pre-requisite: **Nil**

9. Objective: To provide the knowledge of Banach space, Hilbert space, Linear transformation , operators and their properties.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Recapitulatisation of Hölder inequality, Minkowski inequality and vector spaces with examples of $\ell_p$ and $L_p$ spaces. | **2** |
| **2.** | Normed linear spaces, Banach spaces with examples, Convergence and absolute convergence of series in a normed linear space. | **4** |
| **3.** | Inner product spaces, Hilbert spaces, Relation between Banach and Hilbert spaces. Schwarz inequality. | **2** |
| **5.** | Convex sets, Existence and uniqueness of a vector of minimum length, Projection theorem. Orthogonal and orthonormal systems in Hilbert space with examples, Bessel's inequality, Parseval's identity, Characterization of complete orthonormal systems. | **5** |
| **6.** | Continuity of linear maps on normed linear spaces, Four equivalent norms on B(N,N`), Conjugate and Dual spaces, The Riesz Representation Theorem. | **5** |
| **7.** | Adjoint operators, self adjoint operators, normal operators, Unitary operators on Hilbert spaces (H) and their properties. Isometric isomorphism of H onto itself under Unitary operators and their importance . Projection operators on Banach spaces and Hilbert spaces. Orthogonal Projections. | **9** |
| **8.** | Contraction Mappings with examples, Banach–fixed point theorems and applications. | **4** |
| **9.** | Eigenvalues, Eigenvectors and Eigen spaces, Invariant spaces, Spectral Theorem on finite dimensional Hilbert spaces. | **4** |
| **10.** | The Closed Graph Theorem, The Uniform Boundedness Principle and its applications, The Hahn – Banach Extension and Separation Theorems, Open mapping Theorem and applications | **7** |
| | **Total** | **42** |

11. Suggested Books:

| S. No. | Name of Books / Authors/ Publishers | Year of Publication/Reprint |
|---|---|---|
| **1.** | Simons, G. F., "Introduction to Topology and Modern Analysis", McGraw Hill. | **2004** |
| **2.** | Debnath L. K. and Mikusinski P., "Introduction to Hilbert Spaces with Applications", Academic Press. | **2005** |
| **3.** | Bachman G. and Narici L., "Functional Analysis", Academic Press. | **1972** |
| **4.** | Ponnusamy S., "Foundation of Functional Analysis", Narosa Publication. | **2002** |
| **5.** | Jain P. K. and Ahuja O. P., "Functional Analysis", New Age International Publishers. | **2010** |
| **6.** | Nair, M. T., "Functional Analysis: A First Course", PHI Pvt. Ltd. | **2004** |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject code: **CEN-105** Course Title: **Introduction to Environmental Studies**
2. Contact Hours: **L: 3 T: 0 P: 0**
3. Examination Duration (Hrs): **Theory:** 3 **Practical:** 0
4. Relative Weightage: **CWS:** 15 **PRS:** 0 **MTE:** 35 **ETE:** 50 **PRE:** 00
5. Credits: **3** 6. Semester: **Autumn** 7. Subject Area: **GSC**
8. Pre-requisite: **Nil**
9. Objective: To introduce fundamentals of environmental pollution and its control.
10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| 1. | Overview: Environment and Natural Processes; Development (Resource Utilization & Waste Generation); Environmental issues; Concept of Sustainable Development; Issues affecting future development (population, urbanization, health, water scarcity, energy, climate change, toxic chemicals, finite resources etc.); Environmental units | 6 |
| 2. | Air –Water interaction: (Liquid phase-gas phase equilibrium) Henry's Law Constant with units, Dimensionless Henry's Law Constant | 3 |
| 3. | Water –Soil Interaction: Carbonate System (Alkalinity and buffering capacity); Major ions in water; Natural Organic Matter (NOMs); Water quality parameters; Physical processes (Mass Balance): Spatio-temporal variation in quality of river water, lake water, ground water; Water quality standards | 9 |
| 4. | Wetlands, water treatment and wastewater treatment . | 6 |
| 5. | Air resources: Atmosphere; Air pollutants; Emissions and control of air pollutants; Atmospheric meteorology and dispersion; Transport of air (global, regional, local); Air/ atmospheric stability; Plume shape; Gaussian modeling; Air quality standards | 9 |
| 6. | Land pollution and solid waste management | 3 |
| 7. | Ecosystem: Structure and function; Energy flow in ecosystem; Material flow in ecosystem; Biodiversity and ecosystem health; Bio-amplification and bio-magnification | 3 |
| 8. | Hazardous Waste: Definition; Classification; Storage and management; Site remediation; Environmental Risk: assessment, and management | 3 |
| **Total** | | **42** |

11. Suggested Books:

| S. No. | Name of Books / Authors/ Publishers | Year of Publication/ Reprint |
|---|---|---|
| 1. | Davis M. L. and Cornwell D. A., "Introduction to Environmental Engineering", McGraw Hill, New York 4/e | 2008 |
| 2. | Masters G. M., Joseph K. and Nagendran R. "Introduction to Environmental Engineering and Science", Pearson Education, New Delhi. 2/e | 2007 |
| 3. | Peavy H. S., Rowe D.R. and Tchobanoglous G., "Environmental Engineering", McGraw Hill, New York | 1986 |
| 4. | Mines R. O. and Lackey L. W. ""Introduction to Environmental Engineering", Prentice Hall, New Yark | 2009 |
| 5. | Miheicic J. R. and Zimmerman J. B. " Environmental Engineering: Fundamentals, Sustainability, Design" John Wiley and Sons, Inc. | 2010 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Humanities & Social Sciences**

1. Subject Code: **HS-001A** Course Title: **Communication Skills (Basic)**

2. Contact Hours: **L: 1** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weight**:** **CWS** 25 **PRS** 00 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 2 6. Semester**: Autumn/Spring** 7. Subject Area**: HSS**

8. Pre-requisite**: NIL**

9. Objective:
The course intends to build the required communication skills of the students having limited communicative abilities, so that they may communicate effectively in real-life situations

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Understanding the Basics of Communication Skills: Listening, Speaking, Reading & Writing, Scope and Importance | **01** |
| **2.** | Grammar & Composition: Time and Tense, Agreement, Active-Passive, Narration, Use of Determiners, Prepositions & Phrasal Verbs | **05** |
| **3.** | Vocabulary Building & Writing: Word-formation, Synonyms, Antonyms, Homonyms, One-word Substitutes, Idioms and Phrases, Collocations, Abbreviations of Scientific and Technical Words | **02** |
| **4.** | Introduction to Sounds (Vowels & Consonants) Organs of Speech, Place and Manner of Articulation, Stress & Intonation, Listening Comprehension (Practical Sessions in Language Laboratory) | **02** |

| | | |
|---|---|---|
| **5.** | Speaking, Countering Stage-fright and Related Barriers to Communication. | **02** |
| **6.** | Reading and Comprehension: Two lessons to be identified by the department. | **02** |
| | **Total** | **14** |

**List of Practicals:**

1. Ice-breaking Exercises
2. Assignments on Time and Tense, Agreement, Active-Passive
3. Laboratory Session on Narration, Use of Determiners, Prepositions & Phrasal Verbs, Revisionary Exercises & Quiz
4. Laboratory Session on Synonyms, Antonyms, Homonyms
5. Assignments and Practice Sheets on One-word Substitutes, Idioms and Phrases, Collocations, Abbreviations of Scientific and Technical Words
6. Laboratory Session on Practice of sounds, Intonation and Stress, Listening Comprehension
7. Individual presentation, debates, Extempore & Turncoats
8. Exercises in Composition and Comprehension

11. Suggested Books:

| S. No. | Name of Authors / Books / Publishers | Year of Publication/ Reprint |
|---|---|---|
| **1.** | Murphy, Raymond. *Intermediate English Grammar*, New Delhi, Cambridge University Press. | **2009** |
| **2.** | Quirk, Randolph & Sidney Greenbaum. *A University Grammar of English*, New Delhi, Pearson. | **2009** |
| **3.** | McCarthy, Michael & Felicity O' Dell. *English Vocabulary in Use*, New Delhi, Cambridge University Press | **2010** |
| **4.** | Jones, Daniel. *The Pronunciation of English*, New Delhi, Universal Book Stall. | **2010** |
| **5.** | Birchfield, Susan M. *Fowler's Modern English Usage*, New Delhi, OUP. | **2004** |
| **6.** | Llyod, Susan M. *Roget's Thesaurus of English Words and Phrases*. New Delhi: Penguin. | **2010** |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Humanities & Social Sciences**

1. Subject Code: **HS-001B** Course Title: **Communication Skills (Advanced)**

2. Contact Hours: **L: 1** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weight**:** **CWS** 25 **PRS** 00 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 2 6. Semester**: Autumn/Spring** 7. Subject Area**: HSS**

8. Pre-requisite**: NIL**

9. Objective: The course intends to train the learners in using both verbal and non-verbal communication effectively.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| 1. | Advanced Communication Skills: Scope, Relevance, & Importance | 01 |
| 2. | Soft Skills: Interpersonal Communication; Verbal & Non-verbal, Persuasion, Negotiation, Neuro-Linguistic Programming | 03 |
| 3. | Communication and Media (Social and Popular), The Social and Political Context of Communication, Recent Developments and Current Debates in Media | 04 |
| 4. | Cross-cultural and Global Issues in Communication: Race, Ethnicity, Gender & Diaspora | 03 |
| 5. | Rhetoric and Public Communication, Audience Awareness, Emotionality | 03 |
| | **Total** | 14 |

**List of Experiments:**

1. Discussion on the Process of Communication in Personal and Professional Life
2. Group Discussion, Case Studies and Role-Play
3. Assignments on E-mail Etiquette, Social Networking, Blog Writing, Discussions on Current Issues
4. Non-Verbal Communication in Cross-Cultural Situations, Case Studies, Group Discussions and Readings on Topics Related to Race, Ethnicity , Gender and Diaspora
5. Individual Presentations (Audience Awareness, Delivery and Content of Presentation)

11. Suggested Books:

| S. No. | Name of Authors / Books / Publishers | Year of Publication/ Reprint |
|---|---|---|
| **1.** | Rentz, Kathryn, Marie E. Flatley & Paula Lentz. *Lesikar's Business Communication CONNECTING IH A DIGITAL WORLD*, McGraw-Hill, Irwin | **2012** |
| **2.** | Bovee, Courtland L & John V. Thill. *Business Communication Today*. New Delhi, Pearson Education | **2010** |
| **3.** | McMurrey, David A. & Joanne Buckley. *Handbook for Technical Writing*, New Delhi, Cengage Learning. | **2009** |
| **4.** | Jones, Daniel. *The Pronunciation of English*, New Delhi, Universal Book Stall. | **2010** |
| **5.** | Allan & Barbara Pease. *The Definitive Book of Body Language*, New York, Bantam | **2004** |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Humanities and Social Sciences**

1. Subject Code: **HSN-002** Course Title: **Ethics and Self-awareness**

2. Contact Hours: **L: 01** **T: 0 1** **P: 0**

3. Examination Duration (Hrs.): **Theory 2** **Practical 0**

4.Relative Weight**: CWS:25 PRS:0 MTE:25 ETE:50 PRE:0**

5. Credit **02** 6. Semester**: Autumn** 7. Subject Area**: HSSC**

8. Pre-requisite**: NIL**

9. Objective: To introduce the concepts pertaining to ethical and moral reasoning and action and to develop self - awareness.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| 1 | **Introduction**: Definition of Ethics; Approaches to Ethics: Psychological, Philosophical, Social. | **1** |
| 2 | **Psycho-social theories of moral development**: View of Kohlberg; Morality and Ideology, Culture and Morality, Morality in everyday context. | **3** |
| 3 | **Ethical Concerns**: Work Ethics and Work Values, Business Ethics, Human values in organizations. | **3** |
| 4 | **Self-Awareness**: Self Concept: Johari Window, Self and Culture, Self Knowledge, Self-Esteem; Perceived Self-control, Self-serving bias, Self-presentation, Self-growth: Transactional Analysis and Life Scripts. | **4** |
| 5. | **Self Development**: Character strengths and virtues, Emotional intelligence, Social intelligence, Positive cognitive states and processes (Self-efficacy, Empathy, Gratitude, Compassion, and Forgiveness). | **3** |
| | **Total** | **14** |

11. Suggested Books:

| S.No. | Name of Authors / Books / Publishers | Year of Publication |
|---|---|---|
| 1. | Hall, Calvin S., Lindzey, Dardner., & Cambell, John B.,"Theories of Personality",Hamilton Printing Company. | 1998 |
| 2. | Car Alan, "Positive Psychology: The Science of Happiness and Human Strengths", Brunner-Routledge. | 2004 |
| 3. | Leary M.R., "The Curse of Self: Self-awareness, Egotism and the Quality of Human Life", Oxford University Press. | 2004 |
| 4. | Louis P. P., "The Moral Life: An Introductory Reader in Ethics and Literature", Oxford University Press. | 2007 |
| 5. | Corey, G., Schneider Corey, M., & Callanan, P., "Issues and Ethics in the Helping Professions", Brooks/Cole. | 2011 |
| 6. | Snyder, C.R., Lopez, Shane, J., & Pedrotti, J.T., "Positive Psychology" Sage, 2nd edition. | 2011 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Physics**

1. Subject Code: **PHN-001** Course Title: **Mechanics**
2. Contact Hours: **L: 3** **T: 0** **P: 2**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weightage**:** **CWS: 15** **PRS: 25** **MTE: 20** **ETE: 40** **PRE: 0**
5. Credits**: 4** 6. Semester**: Autumn** 7. Subject Area**: BSC**
8. Pre-requisite**: None**
9. Objective: **To familiarize students with the basic principles of mechanics**
10. Details of Course:

| S.No. | Contents | Contact Hours |
|---|---|---|
| 1 | **STATICS OF PARTICLES.** Vectorial representation of forces and moments- Vector Operation-Concepts of Particles and Rigid bodies – Composition of concurrent forces in plane free body Diagram – Equilibrium of Rigid bodies in Two and three dimensions-Moment of a force about a point and about an axis-Couple moment-Reduction of a force system to a force and a couple | 8 |
| 2 | **PROPERTIES OF SURFACES, MOMENTS AND PRODUCTS OF INERTIA** Definition Moment of Inertia for areas-Parallel axis theorem –Perpendicular axis theorem-Moment of inertia for composite area-product of inertia form an area-mass moment of inertia | 6 |
| 4 | **FRICTION** Laws of coulomb friction- Coefficient of Friction-Dry Friction-sliding Friction-Ladder friction-Belt friction – Rolling Resistance. | 4 |
| 5 | **KINEMATICS OF PARTICLES** Principle of virtual work for a particle and rigid body-condition for equilibrium for a conservative system, stability-particle dynamics in rectangular coordinate, cylindrical coordinate and in terms of path variables-General motion of system of particles- | 8 |
| 6 | **WORK ENERGY METHODS, IMPULSE AND MOMENTUM** Work Energy Method-Conservation of Energy-Impulse and Momentum Relation-Impulsive Force-Impact force-Conservation of momentum – Moment of Momentum Equation. | 8 |
| 7 | **RIGID BODY MOTION;** Translation and rotation of rigid bodies- Derivative of a vector fixed in moving reference-General relationship between time derivative of a vector for different references-Moment of momentum equation-kinetic energy of rigid body-work and energy relations-Euler's equation of motion-Three dimensional motion about a fixed point | 8 |
| | **TOTAL** | 42 |

**List of experiments:**

1. Study of magnetic field of a pair of coils in Helmholtz arrangement
2. Determination of e/m
3. Determination of first excitation potential of a gas by Frank-Hertz experiment
4. Determination of Stefan's constant
5. Determination of Planck's constant by radiation
6. To study and verify Malus' law
7. Study of Polarization of light using quarter wave plate
8. Determination of Brewster's angle at glass-air interface
9. Determination of with of a slit by single-slit diffraction pattern
10. Four probe method of finding resistivity of semiconductor
11. Quinck's Method for determining mass susceptibility
12. Wavelength of Na light by Newton's ring method

11. Suggested Books:

| S.No. | Title/Authors/Publishers | Year of Publication |
|---|---|---|
| 1. | Shames I.H. and Rao G.K., "Engineering Mechanics-Statics and Dynamics" ,4 Edition, Pearson Education | 2006 |
| 2. | Beer F.P and Johnson E.R., "Vector Mechanics for Engineers- Statics and Dynamics",9 Edition, Tata McGraw-Hill Publishing Company | 2010 |
| 3. | Pytel A. and Kiusalaas J., " Engineering Mechanics: Statics" 3rd Edition, Cengage Learing | 2010 |
| 4. | Pytel A. and Kiusalaas J., " Engineering Mechanics: Dynamics"3rd Edition Cengage Learing | 2010 |
| 5. | Hibberler R.C and Gupta A., Engineering Mechanics,", 12th Edition, Pearson Education | 2012 |
| 6. | Meriam J.L. and Kraige L.G., "Engineering Mechanics: Statics", 6th Edition, John Willey and Son,s | 2012 |
| 7. | Meriam J.L., and Kraige L.G., "Engineering Mechanics: Dynamics", 6th Edition , John Willey and Son's | 2012 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MAN-004** Course Title: **Numerical Methods**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weightage**:** **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: BSC**

8. Pre-requisite**: Nil**

9. Objective: To introduce various numerical methods to get approximation solutions.

10. Details of Course:

| S.No. | Contents | Contact Hours |
|---|---|---|
| **1** | **Error Analysis**: Exact and approximate numbers, Rounding of numbers, Significant digits, Correct digits, various types of errors encountered in computations, Propagation of errors. | **3** |
| **2** | **Solution of system of linear equations**: (i) Direct methods: Gauss elimination method without pivoting and with pivoting, LU-decomposition method. (ii) Iterative methods: Jacobi and Gauss-Seidel methods. | **8** |
| **3** | **Roots of non-linear equations**: Bisection method, Regula-Falsi method, Newton-Raphson method, direct iterative method with convergence criteria, Newton-Raphson method for solution of a pair of non-linear equations. | **6** |
| **4** | **Eigen values and Eigen vectors**: Dominant and smallest Eigen values/Eigen vectors by power method. | **3** |
| **5** | **Interpolation**: Finite difference operator and their relationships, difference tables, Newton, Bessel and Stirling's interpolation formulae, Divided differences, Lagrange interpolation and Newton's divided difference interpolation. | **6** |
| **6** | **Numerical differentiation**: First and second order derivatives by various interpolation formulae. | **4** |
| **7.** | **Numerical integration:** Trapezoidal, Simpsons $1/3^{rd}$ and $3/8^{th}$ rules with errors and their combinations, Gauss Legendre 2-points and 3-points formulae | **6** |
| **8.** | **Solution of first and second order ordinary differential equations:** Picard's method, Taylor's series method, Euler, Modified Euler, Runge-Kutta methods and Milne's method. | **4** |
| **9.** | Case studies | **2** |
| | **Total** | **42** |

11. Suggested Books:

| S.No. | Name of Authors / Books / Publishers | Year of Publication/ Reprint |
|---|---|---|
| 1 | Gerald, C. F. and Wheatly, P. O.," Applied Numerical Analysis", 6th Edition, Wesley. | 2002 |
| 2 | Jain, M. K., Iyengar, S. R. K. and Jain, R. K., "Numerical Methods for Scientific and Engineering Computation", New Age Pvt. Pub, New Delhi. | 2000 |
| 3 | Conte, S. D. and DeBoor, C., "Elementary Numerical Analysis", McGraw-Hill Publisher | 1982 |
| 4 | Krishnamurthy, E. V. & Sen, S. K., "Applied Numerical Analysis", East West Publication. | 1998 |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE **:** **Department of Physics**

1. Subject Code**:** **PHN-008** Course Title**: Electromagnetic Theory**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory : 3** **Practical : 0**

4. Relative Weightage**:** **CWS: 25** **PRS: 0** **MTE : 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: BSC**

8. Pre-requisite**: None**

9. Objective: To impart basic concepts of electromagnetism and their applications in engineering.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| 1 | **Vector Algebra:** Cartesian, Cylindrical and Spherical coordinate Systems, Constant coordinate surfaces, Del operator, Gradient, Divergence of a Vector and Divergence Theorem, Curl of a vector and Stokes theorem, Gradient, Divergence, Curl and Laplacian in the three coordinate Systems, Laplacian of a scalar, Scalar & Vector Fields, Classification of Vector fields. | **9** |
| 2 | **Electrostatics:** Coulomb's law, electric field intensity due to continuous charge distribution, Gauss's law & its applications, electric potential, the line integral, electric dipole and flux lines, energy density in an electrostatic field, electrostatic discharge. Current and current density, metallic conductors, conductor properties and boundary conditions, polarization in dielectrics, nature of Dielectric materials and related boundary conditions, capacitance.Electrostatic boundary-value problems, Laplace's and Poisson's equations, Uniqueness theorem, General procedure for solving Laplace's and Poisson's equation. | **11** |
| 3 | **Magnetostatics:** Biot-Savart's law, Ampere's circuital law, Applications of Ampere's law, Magnetic flux and magnetic flux density, Scalar and vector magnetic potentials.Magnetic dipole, Force due to Magnetic field on a differential current element, force between two differential current elements, Force and torque on a closed circuit, The nature of magnetic materials, Magnetization and permeability, Magnetic boundary conditions, Inductors, inductances, Magnetic energy, Magnetic circuits, Potential energy and force on magnetic materials, magnetic levitation. | **11** |

| | | |
|---|---|---|
| **4** | **Time varying electric and magnetic fields and electromagnetic waves:**<br>Faraday's law, transformer, EMF, DC motors, displacement current, Maxwell's equations for time varying fields, electromagnetic wave equation in free space, plane waves in free space, polarization, Poynting vector and power associated with electromagnetic waves, plane waves in lossless, homogeneous, and isotropic dielectric, reflection and transmission of plane waves at dielectric interface, normal and oblique incidence, plane waves in good conductors, skin depth. Microwaves and their applications in telecommunication, radar, and heating. | **11** |
| | **Total** | **42** |

11. Suggested Books:

| S.No. | Name of Authors / Books / Publishers | Year of Publication/ Reprint |
|---|---|---|
| **1.** | William H Hayt, Jr., and John A. "Engineering Electromagnetics", Buck, Tata McGraw Hill Publishing Company Ltd, New Delhi, 7th Ed. | **2005** |
| **2.** | Matthew N.O. Sadiku,"Elements of Engineering Electromagnetics" , Oxford University Press, 3rd Ed. | **2003** |
| **3.** | Nannapaneni Narayan Rao, "Elements of Engineering Electromagnetics", Prentice Hall of India, New Delhi, 4th Ed. | **2000** |
| **4.** | D.J. Griffiths, "Introduction to Electrodynamics", Prentice Hall, 3rd Ed. | **2000** |

# INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MAN-001** Course Title: **Mathematics I**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 00 25 50 0

5. Credits**:** 4 6. Semester**: Autumn** 7. Subject Area**: BSC**

8. Pre-requisite**:** **None**

9. Objective: **To provide essential knowledge of basic tools of Differential Calculus, Integral Calculus , Vector Calculus and Matrix Algebra for degree students.**

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | **Matrix Algebra:** Elementary operations and their use in getting the Rank, Inverse of a matrix and solution of linear simultaneous equations. Orthogonal, Symmetric, Skew-symmetric, Hermitian, Skew-Hermitian, Normal & Unitary matrices and their elementary properties. Eigen-values and Eigenvectors of a matrix, Cayley-Hamilton theorem, Diagonalization of a matrix. | **8** |
| **2.** | **Differential Calculus:** Limit, Continuity and differentiability of functions of two variables, Euler's theorem for homogeneous equations, Tangent plane and normal. Change of variables, chain rule, Jacobians, Taylor's Theorem for two variables, Error approximations. Extrema of functions of two or more variables, Lagrange's method of undetermined multipliers | **12** |
| **3.** | **Integral Calculus:** Review of curve tracing and quadric surfaces, Double and Triple integrals, Change of order of integration. Change of variables. Gamma and Beta functions. Dirichlet's integral. Applications of Multiple integrals such as surface area, volumes, centre of gravity and moment of inertia.. | **12** |
| **4.** | **Vector Calculus:** Differentiation of vectors, gradient, divergence, curl and their physical meaning. Identities involving gradient, divergence and curl. Line and surface integrals. Green's, Gauss and Stroke's theorem and their applications. | **10** |
| | **Total** | **42** |

11. Suggested Books:

| S. No. | Name of Authors/ Books/Publishers | Year of Publication/Reprint |
|---|---|---|
| 1. | E. Kreyszig, Advanced Engineering Mathematics, 9th edition, John Wiley and Sons, Inc., U.K. | 2011 |
| 2. | R.K. Jain and S.R.K. Iyenger, Advanced Engineering Mathematics, 2nd Edition, Narosa Publishing House. | 2005 |
| 3. | M.D. Weir, J. Hass, F.R. Giordano, Thomas' Calculus, 11th Edition, Pearson Education. | 2008 |

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Civil Engineering**

1. Subject Code: **CE-142** Course Title: **Fluid Mechanics**

2. Contact Hours: **L: 3** **T: 1** **P: 2/2**

3. Examination Duration (Hrs.): **Theory** [3] **Practical** [0]

4. Relative Weightage: **CWS** [15] **PRS** [15] **MTE** [30] **ETE** [40] **PRE** [0]

5. Credits: [4] 6. Semester: **Spring** 7. Subject Area: **DCC**

8. Pre-requisite: **Nil**

9. Objective: To introduce fundamentals of stagnant, flowing fluid and flow through different conduits.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| 1. | **Introduction:** Fluid properties, types of fluids, continuum principle | 3 |
| 2. | **Principles of Fluid Statics:** Basic equations, manometers, hydrostatic forces on submerged surfaces, buoyancy. | 7 |
| 3. | **Kinematics of Flow:** Visualisation of flow, types of flow, streamline, pathline, streakline, principle of conservation of mass, velocity, acceleration, velocity potential and stream function, vorticity, circulation. | 4 |
| 4. | **Fluid Dynamics:** Control volume approach, Euler's equation, Bernoulli's equation and its applications, Reynolds transport theorem, momentum and angular momentum equations and their applications. | 7 |
| 5. | **Dimensional Analysis and Similitude:** Dimensional homogeneity, Buckingham's $\pi$ theorem, dimensionless numbers, similitude. | 3 |
| 6. | **Boundary Layer Theory:** Concept of boundary layer, laminar and turbulent boundary layers, boundary layer thickness, von Karman integral equation, laminar sublayer, hydrodynamically smooth and rough boundaries, separation of flow and its control, cavitation. | 6 |
| 7. | **Laminar and Turbulent Flow through Pipes:** Laminar flow through pipes, turbulent flow, Reynolds equations, Prandtl's mixing length theory, velocity distribution over a flat plate and in a pipe section, Darcy-Weisbach equation, friction factor, Moody diagram, minor losses, pipe networks, Venturimeter, orifice meter, water hammer, surge tanks | 9 |

| | | |
|---|---|---|
| 8. | **Drag and Lift:** Skin-friction and form drag, drag on sphere, cylinder and flat plate, Karman vortex shedding, generation of lift around a cylinder, lifting vanes. | 3 |
| | **Total** | 42 |

11. Suggested Books:

| S. No. | Name of Books / Authors | Year of Publication |
|---|---|---|
| 1. | Som, S.K. and Biswas, G., "Fluid Mechanics", Tata McGraw Hill. | 1998 |
| 2. | Garde, R.J. and Mirajgaoker, A.G., "Engineering Fluid Mechanics", Nem Chand & Bros. | 1988 |
| 3. | Fox, R.W. and McDonald, A.T., "Introduction to Fluid Mechanics", John Wiley & Sons. | 2004 |
| 4. | Asawa, G.L., "Fluid Flow in Pipes and Channels", CBS Publishers | 2008 |
| 5. | Schlichting, H. and Gersten, K., "Boundary Layer Theory", Springer. | 2004 |
| 6. | Streeter, V.L. and Benjamin, W.E., "Fluid Mechanics", McGraw-Hill. | 1983 |