Syllabi of the Department Elective Courses for Integrated M.Sc. in Applied Mathematics

Program Code: **312** **Integrated M. Sc. (Applied Mathematics)**

Department Code: **MA** **MATHEMATICS**

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
Department Elective Courses (MA Elective-I and MA Elective-II) to be chosen in Third Year														
1.	MAN-321	Biomathematics	DEC	3	3	0	0	3	0	25	-	25	50	-
2.	MAN-322	Combinatorial Mathematics	DEC	3	3	0	0	3	0	25	-	25	50	-
3.	MAN-323	Computer Graphics	DEC	3	3	0	0	3	0	25	-	25	50	-
4.	MAN-324	Fuzzy Sets and Fuzzy Logics	DEC	3	3	0	0	3	0	25	-	25	50	-
5.	MAN-325	Mathematical Imaging Techniques	DEC	3	3	0	0	3	0	25	-	25	50	-
6.	MAN-326	Numerical Optimization	DEC	3	3	0	0	3	0	25	-	25	50	-
Department Elective Courses (MA Elective-III and MA Elective-IV) to be chosen in Fourth Year														
1.	MAN-521	Advanced Graph Theory	DEC	3	3	0	0	3	0	25	-	25	50	-
2.	MAN-522	Computer Vision	DEC	3	3	0	0	3	0	25	-	25	50	-
3.	MAN-523	Control Theory	DEC	3	3	0	0	3	0	25	-	25	50	-
4.	MAN-524	Integral Equations and Calculus of Variations	DEC	3	3	0	0	3	0	25	-	25	50	-
5.	MAN-525	Robotics and Control	DEC	3	3	0	0	3	0	25	-	25	50	-
6.	MAN-526	Soft Computing	DEC	3	3	0	0	3	0	25	-	25	50	-
7.	MAN-527	Stochastic Process	DEC	3	3	0	0	3	0	25	-	25	50	-
Department Elective Courses (MA Elective-V, MA Elective-VI and MA Elective-VII) to be chosen in Fifth Year														
1.	MAN-621	Abstract Harmonic Analysis	DEC	3	3	0	0	3	0	25	-	25	50	-
2.	MAN-622	Algebraic Number Theory	DEC	3	3	0	0	3	0	25	-	25	50	-
3.	MAN-623	Algebraic Topology	DEC	3	3	0	0	3	0	25	-	25	50	-
4.	MAN-624	Approximation Theory	DEC	3	3	0	0	3	0	25	-	25	50	-
5.	MAN-625	Coding Theory	DEC	3	3	0	0	3	0	25	-	25	50	-
6.	MAN-626	Commutative Algebra	DEC	3	3	0	0	3	0	25	-	25	50	-
7.	MAN-627	Dynamical Systems	DEC	3	3	0	0	3	0	25	-	25	50	-
8.	MAN-628	Evolutionary Algorithms	DEC	3	3	0	0	3	0	25	-	25	50	-
9.	MAN-629	Financial Mathematics	DEC	3	3	0	0	3	0	25	-	25	50	-
10.	MAN-630	Finite Element Methods	DEC	3	3	0	0	3	0	25	-	25	50	-
11.	MAN-631	Multivariate Techniques	DEC	3	3	0	0	3	0	25	-	25	50	-
12.	MAN-632	Optimal Control Theory	DEC	3	3	0	0	3	0	25	-	25	50	-
13.	MAN-633	Orthogonal Polynomials and Special Functions	DEC	3	3	0	0	3	0	25	-	25	50	-
14.	MAN-634	Parallel Computing	DEC	3	3	0	0	3	0	25	-	25	50	-
25.	MAN-635	Wavelet Theory	DEC	3	3	0	0	3	0	25	-	25	50	-

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-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** 25 **PRS** 0 **MTE** 25 **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 linear stability analysis, Introduction to Discrete Models, Linear Models, Growth models, Decay models, Drug Delivery	**10**

	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: **Department of Mathematics**

1. Subject Code: **MAN-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** **25** **PRS** **0** **MTE** **25** **ETE** **50** **PRE** **0**

5. Credits**:** **3** 6. Semester**: 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: **Department of Mathematics**

1. Subject Code: **MAN-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** **25** **PRS** **0** **MTE** **25** **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: **Department of Mathematics**

1. Subject Code: **MAN-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** 25 **PRS** 0 **MTE** 25 **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, extension principle, fuzzy mapping, interval analysis, vertex method and DSW algorithm.	5
7	**Fuzzy Optimization:** One dimensional fuzzy optimization, fuzzy concept variables and casual relations, fuzzy cognitive maps, agent based models.	5
8	**Fuzzy Control Systems:** 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: **Department of Mathematics**

1. Subject Code: **MAN-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** **25** **PRS** **0** **MTE** **25** **ETE** **50** **PRE** **0**

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

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

9. Objective: 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 fundamentals:** A simple image formation model, sampling and quantization, connectivity and adjacency relationships between pixels	**3**
2.	**Spatial domain 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 restoration:** 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 reconstruction:** 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: **Department of Mathematics**

1. Subject Code: **MAN-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 **25** PRS **0** MTE **25** 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 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: **Department of Mathematics**

1. Subject Code: **MAN-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 **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **3** 6. Semester: **: Autumn/Spring** 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 parameters, eigen values of regular graphs, eigenvalues and expanders, strongly regular graphs.	**4**
	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: **Department of Mathematics**

1. Subject Code: **MAN-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** **25** **PRS** **0** **MTE** **25** **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 detection and 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 from 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: **Department of Mathematics**

1. Subject Code: **MAN-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** 25 **PRS** 0 **MTE** 25 **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: **Department of Mathematics**

1. Subject Code: **MAN-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** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

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

8. Pre-requisite**: Nil**

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 Integral Equations:** 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 of integral equations by transform methods:** Singular integral equations, Hilbert-transform, Cauchy type integral equations.	6
6.	**Calculus of Variations:** 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: **Department of Mathematics**

1. Subject Code: **MAN-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** 25 **PRS** 0 **MTE** 25 **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: **Department of Mathematics**

1. Subject Code: **MAN-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 **25** PRS **0** MTE **25** 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: **Department of Mathematics**

1. Subject Code: **MAN-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** **25** **PRS** **0** **MTE** **25** **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 Chains:** 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 Markov Chains:** 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 Department

1. Subject Code: MAN-528 **Course Title:** Simulation Techniques

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

3. Examination Duration (Hrs) Theory - 3 hours Practical -

4. Relative Weightage: CWS 10-25 PRS 25 MTE 15-25 ETE 30-40 PRE 00

5. Credits: 4

6. Semester: Autumn/Spring

7. Subject Area: PEC

8. Pre-requisite: Knowledge of basic probability and statistics and any programming language

9. Objective: To impart knowledge of some simulation techniques with applications (particularly in finance)

10. Details of Course:

S.No.	Contents	Contact Hours
1.	Pseudo-random number generators, generator based on linear recurrences, add-with-carry and subtract-with-borrow generators, non-linear generators, theoretical tests for PRNGs based on recurrence modulo 2, statistical tests	3
2.	General sampling method, inverse transform method, acceptance-rejection method, composition, convolution and other useful identities, generating variates from standard distributions such as normal, gamma, exponential, beta, Poisson, binomial, normal random vector, Box-Muller method	11
3.	Variance reduction techniques, control variate method, antithetic variate method, importance sampling, stratified sampling, Latin hypercube sampling, moment-matching method, conditional Monte Carlo	12
4.	Quasi-Monte Carlo method, basic principles, lattices, digital nets and sequences, solo sequence, Faure sequence, Niederreiter sequence	10
5.	Application in finance, European option pricing under log normal model, randomised quasi-Monte Carlo American option pricing, estimating sensitivities and percentiles	6
	Total	**42**

11. Suggested Books:

S.No.	Name of the Authors/Books/Publishers	Year of Publication
1.	G. S. Fishman, “Monte Carlo: Concepts, Algorithms, and Applications”, Springer	1996
2.	P. Glasserman, “Monte Carlo Methods in Financial Engineering”, Springer	2003
3.	C. Lemieux, “Monte Carlo and Quasi-Monte Carlo Sampling”, Springer	2009
4.	J. C. Hull, “Options, Futures and Other Derivatives”, Prentice Hall	2002
5.	P. E. Kloeden and E. Platen, “Numerical Solution of Stochastic Differential Equations”, Springer-Verlag	1992
6.	A. M. Law and W. D. Kelton, “Simulation Modeling and Analysis”, McGraw-Hill, inc.	1991
7.	Sheldon Ross, “A First Course in Probability”, Pearson	2013

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-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** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Spring** 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
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: **Department of Mathematics**

1. Subject Code: **MAN-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** **25** **PRS** **0** **MTE** **25** **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: **Department of Mathematics**

1. Subject Code: **MAN-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** **25** **PRS** **0** **MTE** **25** **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: **Department of Mathematics**

1. Subject Code: **MAN-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** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

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

8. Pre-requisite**:** **Real Analysis and Functional 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
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 Publishing Co.	**1964**
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: **Department of Mathematics**

1. Subject Code: **MAN-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** **25** **PRS** **0** **MTE** **25** **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. 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. No.	Title/Authors/Publishers	Year of 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 (3rd 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 (3rd ed.)	**1998**
7.	Moon, T. K.: "*Error Correction Coding*", John Wiley & Sons	**2005**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-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** **25** **PRS** **0** **MTE** **25** **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: **MAN-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** 25 **PRS** 0 **MTE** 25 **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 Dynamical Continuous Systems:** 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 systems:** Logistic maps, equilibrium points and their local stability, cycles, period doubling, chaos, tent map, horse shoe map.	6
5.	**Deterministic chaos:** 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: **MAN-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 **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **3** 6. Semester: **: Autumn/Spring** 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: **Department of Mathematics**

1. Subject Code: **MAN-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** **25** **PRS** **0** **MTE** **25** **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: **Department of Mathematics**

1. Subject Code: **MAN-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** **25** **PRS** **0** **MTE** **25** **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: **Department of Mathematics**

1. Subject Code: **MAN-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** 25 **PRS** 0 **MTE** 25 **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
1.	Multivariate Normal Distribution: Joint and marginal densities, independence, estimation of mean vector and covariance matrix	**8**
2.	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**
3.	Estimation, confidence intervals and tests of significance and prediction of new values	**4**
4.	Multiple Regression Analysis: graphical procedure, assumptions, methods for estimation of model, Determining Best Estimates.	**6**
5.	Test for significant overall regression, Partial F and multiple F Tests, Partial and multiple correlation and their relationship with multivariate normal distribution.	**4**
6.	Confounding and interaction in regression, regression diagnostics, residual analysis, collinearity.	**4**
7.	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**
8.	ANOVA: Basic concepts, Gauss Markoff theorem, One way classification, comparison of more than two means, statistical model and analysis for one way layout, two way classification, statistical model and analysis for two way layout, analysis of variance using linear models One way and Two way classification	**6**
	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: **MAN-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** **25** **PRS** **00** **MTE** **25** **ETE** **50** **PRE** **00**

5. Credits**:** **3** 6. Semester**: Autumn/Spring** 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 Control Problems**: General optimal control problem, Formulation for economic growth, Resource depletion, Exploited populations, Advertising policies and rocket trajectories servo problems.	8
2.	**Variational Approach**: 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 Approach**: 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: **Department of Mathematics**

1. Subject Code: **MAN-633** 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** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Autumn/Spring** 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 functions:** 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 continuation:** 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 series:** 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 polynomials**: 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. Sister Celine's techniques for finding pure recurrence relation. Characterization: Appell, Sheffes and s-type characterization of polynomial sets.	8
	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: **Department of Mathematics**

1. Subject Code: **MAN-634** 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 **25** PRS **0** MTE **25** 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 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: **Department of Mathematics**

1. Subject Code: **MAN-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** 25 **PRS** 0 **MTE** 25 **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 ℓ_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**