IV Sem

MAT602: WAVELETS

Theory: 75%

UNIT I: The discrete Fourier transform and the inverse discrete Fourier transform, their basic properties and computations. The fast Fourier transform. The discrete cosine transform and the fast cosine transform.

UNIT II: Construction of wavelets on $\mathbb{Z}_N$. First stage and by iteration. The Haar system. Shannon wavelets. Daubechies' D6 wavelets on $\mathbb{Z}_N$. Description of $l^2(\mathbb{Z})$, $L^2[-\pi,\pi)$, $L^2(\mathbb{R})$, their orthonormal bases. Fourier transform and convolution on $l^2(\mathbb{Z})$, wavelets on $\mathbb{Z}$. Haar wavelets on $\mathbb{Z}$. Daubechies' D6 wavelets for $l^2(\mathbb{Z})$.

UNIT III: Orthonormal bases generated by a single function in $L^2(\mathbb{R})$. Fourier transform and inverse Fourier transform of a function f in $L^1(\mathbb{R}) \cap L^2(\mathbb{R})$, Parseval's relation, Plancherel's formula, Orthonormal wavelets in $L^2(\mathbb{R})$, Balian-Low theorem.

UNIT IV: Multi-resolution analysis and MRA wavelets, certain function in $L^2(\mathbb{R})$ for which $\{\psi_{j,k}\}$ does not form an orthonormal system, compactly supported wavelets, band-limited wavelets.

UNIT V: Franklin wavelets on $\mathbb{R}$. Dimension function. Characterization of MRA wavelets (Sketch of the proof). Minimally Supported Wavelets. Wavelet Sets. Characterization of two-interval wavelet sets. Shannon wavelet. Journe's wavelet. Decomposition and reconstruction algorithms of Wavelets.

Lab-work: 25%

The following lab work is recommended:

1. To plot a member in $l^2(\mathbb{Z}_N)$, its Fourier transform and its inverse Fourier transform.
2. To verify various identities relating Fourier transform, inverse Fourier transform, inner product, norm and convolution.
3. Computing Fourier coefficients of an element of $l^2(\mathbb{Z}_N)$, with respect to a given wavelet (Haar, Daubechies' D6) at a certain level such as $\langle z, \psi_{-2,k} \rangle$ etc.

Books Recommended:

1. Michael W. Frazier, An Introduction to Wavelets through Linear Algebra, Springer-Verlag, 1999.
2. Eugenio Hernandez and Guido Weiss, A First Course on Wavelets, CRC Press, 1996.

Further Reading:

1. C. K. Chui, An Introduction to Wavelets, Academic Press, 1992.
2. Ingrid Daubechies, Ten Lectures on Wavelets, CBS-NFS Regional Conferences.

MAT652: ADVANCED FLUID MECHANICS

UNIT-I: Stress Principle of Cauchy, Equations for conservation of linear and angular Momentum, Constitutive equations for Newtonian fluids; Navier- Stokes equations in Vector and Tensor forms, Navier- Stokes equations in orthogonal coordinate systems (particularly in Cartesian, cylindrical and spherical coordinate systems).

UNIT-II: Vorticity equations; Energy dissipation due to viscosity, Dynamical similarity and dimensionless numbers and their significance in the fluid dynamics, Some Exact solutions -- Fully developed plane Poiseuille and Couette flows between parallel plates, Steady flow between pipes of uniform cross-section.

UNIT-III: Couette flow between coaxial rotating cylinders, Small Reynolds number flow – Flow between steadily rotating spheres, Stokes equations, Dynamic equation satisfied by stream function, Relation between pressure and stream function; General stream function solution of Stokes equations in spherical polar coordinates; Steady flow past a sphere; Drag on a body.

UNIT-IV: Flow past a circular cylinder, Stokes paradox, Oseen's equations, Elementary ideas about perturbation and cell methods as applied to slow flow problems, Boundary layer concept.

Unit-V: Two-dimensional boundary layer equations, separation phenomena, Boundary layer on a semi-infinite plane, Blasius equation and solution, Karman's Integral method, Displacement thickness, Momentum thickness and Energy thickness.

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Reference books:

1. Z.U.A. Warsi, Fluid Dynamics, CRC Press (2005)
2. J. Happel and H. Brenner, Low Reynolds Number Hydrodynamics, Kluwer Academic Publishers group, (1983)
3. W.E. Langlois, Slow Viscous flow, Macmillan, (1964)
4. T.C. Papanastasiou, G.C.Georgiou, A.N.Alexandrou, Viscous Fluid Flow, CRC Press (2000).
5. N. Curle &H.J. Davies, Modern Fluid Dynamics (Vol.-I), D.Van Nostrand Comp. Ltd. (London), (1964)

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MAT [illegible]: NONLINEAR ANALYSIS

UNIT ONE: Contractions in Metric spaces, Measure of Noncompactness, Normed spaces, Banach spaces, Hilbert spaces, Uniformly convex, strictly convex and reflexive Banach spaces, Lipschitzian and contraction mappings, Banach's contraction principle, Application to Volterra and Fredholm integral equations.

UNIT TWO: Nonexpansive, asymptotically nonexpansive, accretive and quasinonexpansive mappings, Fixed point theorems for nonexpansive mappings, Nonexpansive operators in Banach spaces satisfying Opial's condition, The demiclosedness principle.

UNIT THREE: Schauder's fixed point theorem, Condensing maps, Fixed points for condensing maps, The modulus of convexity and normal structure, [illegible] [illegible]'s fixed point theorem, Set-valued mappings.

UNIT FOUR: Fixed point iteration procedures, The Mann iteration, Lipschitzian and Pseudocontractive operators in Hilbert spaces, Strongly pseudocontractive operators in Banach spaces, The Ishikawa iteration, Stability of fixed point iteration procedures.

~~**UNIT FIVE:** Iterative solution of Nonlinear operator equations in arbitrary and smooth Banach spaces, Nonlinear m-accretive operator, Equations in reflexive Banach spaces.~~

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Books Recommended:

1. V. Berinde, Iterative Approximation of Fixed Points, Lecture Notes in Mathematics, No. 1912, Springer, 2007.
2. M. A. Khamsi and W. A. Kirk, An Introduction to Metric Spaces and Fixed Point Theory, John Wiley & Sons, New York, 2001.
3. [illegible] Approximation: The KKM-map Principle, Kluwer Academic Publishers, Dordrecht, The Netherlands, 1997.
4. V. I. Istratescu, Fixed Point Theory, An Introduction, D. Reidel Publishing Co., 1981.
5. K. Goebel and W. A. Kirk, Topic in Metric Fixed Point Theory, Cambridge University Press, 1990.

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MAT[illegible] REPRESENTATION THEORY OF FINITE GROUPS

UNIT ONE: Irreducible and completely reducible modules, Schur's Lemma, Jacobson density Theorem, Wedderburn Structure theorem for semisimple modules and rings. Group Algebra, Maschke's Theorem.

UNIT TWO: Representations of a group on a vector space, matrix representation of a group, equivalent and non-equivalent representations, Decomposition of regular representation, Number of irreducible representations.

UNIT THREE: Characters, irreducible characters, Orthogonality relations, Integrality properties of characters, character ring, Burnside's $p^a q^b$ - Theorem.

UNIT FOUR: Representations of direct product of two groups, Induced representations, The character of an induced representations, Frobenius reciprocity Theorem. Construction of irreducible representations of Dihedral group D_n, Alternating group A_4, Symmetric groups S_4 and S_5.

~~**UNIT FIVE:** Mackey's irreducibility criterion, Clifford's Theorem, Statement of Brauer and Artin's Theorems.~~

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Books Recommended:

1. M. Burrow, Representation Theory of Finite Groups, Academic Press, 1965.
2. L. Dornhoff, Group Representation Theory, Part A, Marcel Dekker, Inc., New York, 1971.
3. N. Jacobson, Basic Algebra II, Hindustan Publishing Corporation, New Delhi, 1983.
4. S. Lang, Algebra, 3rd ed., Springer, 2004.
5. J. P. Serre, Linear Representation of Groups, Springer-Verlag, 1977.

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A Ahmed
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MAT 664: CONTACT MANIFOLDS

Unit I: Contact manifolds. Definition, Examples, Almost contact manifolds, Killing vector field, The tensor field h, Curvature properties of contact metric manifolds

Unit II: K-contact Manifolds, Characterizations of K- contact manifolds, Curvature properties. Sectional curvature, Locally symmetric K- contact manifolds.

Unit III: Sasakian manifolds, Curvature properties, ϕ- sectional curvature of a Sasakian manifold, cosymplectic manifolds, Sasakian space forms.

Unit IV: Cosymplectic manifolds, Nearly cosymplectic manifolds, cosymplectic space forms, trans- Sasakian manifolds, , 3- dimensional trans- Sasakian manifolds.

Unit V: Para contact manifolds, Examples, Torsion tensor fields, Integrability of almost para contact structure, Para- Sasakian manifolds, LP- Sasakian manifolds.

References:

1. D. E. Blair, Riemannian Geometry of Contact and Symplectic Manifolds, Birkhauser, 2010.
2. K. Yano & M. Kon, Structures on Manifolds, World Scientific, 1984.

MAT 666: Dynamical Systems

UNIT ONE: Dynamical systems, Iterates of a function, trajectories and orbits, recursion equations, phase portraits, the logistic function.

UNIT TWO: Review of metric spaces, topology of IR and analysis of real functions, fixed (or equilibrium) points, periodic points, asymptotic points, stable sets, graphical analysis.

UNIT THREE: Sarkovskii's ordering, Sarkovskii's theorem, sufficient conditions for a function on a closed interval to have a unique fixed point, dynamical information from a differentiable function, hyperbolic and nonhyperbolic periodic points, attracting periodic points.

UNIT FOUR: σ-algebras and subalgebras, measure algebras, atoms of a measure algebra and the Caratheodory's theorem, symbol space, shift maps, topologically transitive functions, sensitive dependence, chaotic functions, topological conjugates.

UNIT FIVE: Measure preserving transformations, definitions and examples, construction of a new measure preserving transformation from given ones, homomorphisms, isomorphisms, recurrence property of a measure preserving transformation, Poincare's recurrence theorem, introduction to ergodicity.

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References:

(1) R. A. Holmgren, A First Course in Discrete Dynamical Systems, Springer-Verlag, 1994.
(2) H. L. Roydenand P. M. Fitzpatrick, Real Analysis (Fourth Edition), Prentice Hall, 2010.
(3) P. Walters, An Introduction to Ergodic Theory, Springer, 1982.

Further Reading:

(1) R. L. Devaney, An Introduction to Chaotic Dynamical Systems, Second Edition, Addison- Wesley, 1989.
(2) K. R. Parthsarthy, Introduction to Probability and Measure, Hindustan Book Agenc, 2005.

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