Syllabus of M. Tech. in Computational Seismology

Credit requirements :

(a) Minimum credit to be earned for award of degree: 73

(b) Minimum credit to be registered in a semester : 15

Duration: Minimum: Two years (4 Semesters) Maximum: Four years (8 Semesters)

Semester-I

Course Code	Course Title	L	T	P	Credit	CH
SM - 611	Continuum Mechanics	3	1	0	4	4
SM - 612	Stochastic Processes & Time Series Analysis	3	1	0	4	4
SM - 613	Physics of the Earth and Geodynamics	3	1	0	4	4
SM - 614	Computational Techniques & Prograaming	3	1	0	4	4
SM - 615	Finite Element Methods and Numerical Techniques	3	1	0	4	4
SM - 610	Computational Laboratory I	0	0	5	5	10

Semester-II

Course Code	Course Title	L	T	P	Credit	CH
SM - 621	Mathematical Methods in Seismology	3	1	0	4	4
SM - 622	Inverse Theory and Statistical Inference	3	1	0	4	4
SM - 623	Computational Seismology	3	1	2	6	8
SM- 631- 9	Elective	3	1	0	4	4
SM - 620	Computational Laboratory II	0	0	6	6	12
SM - 640	M.Tech Dissertation --I	0	0	0	10	-
SM - 650	M.Tech Dissertation-II	0	0	0	14	-

Elective Courses: Any one Course has to be adopted (the list is only suggestive)

SM - 631	Computer Graphics and Visualization	3	1	0	4	4
SM - 632	Pattern Recognition in Geo-sciences	3	1	0	4	4
SM - 634	Digital Signal Processing	3	1	0	4	4
SM - 635	Advances in Seismology	3	1	0	4	4
SM - 637	Structural Dynamics & Earthquake Engineering	3	1	0	4	4
SM - 638	Fuzzy Set Theory & Applications	3	1	0	4	4
SM - 639	Geo-informatics & Data Analysis	3	1	0	4	4

Semester – III (Project Work)

Course Code	Course Title	L	T	P	Credit	CH
SM - 640	M.Tech Dissertation --I	0	0	0	10	-

Semester-IV (Project Work)

Course Code	Course Title	L	T	P	Credit	CH
SM - 650	M.Tech Dissertation-II	0	0	0	14	-

Detailed Syllabus

SM 611: Continuum Mechanics 3-1-0-4

Tensors - Stress & Strain: The stress tensor, the strain tensor. The linear stress- strain relationship. Scalar, Contravarient and Covariant Tensors, Rank, Symmetric and Antisymatric Tensors, Algebraic operations on tensors, Matrix Tensor: Fundamental Tensors, Differentiation of Tensors, Tensor form of Gradient, divergence, Laplacian and Curl.

Fluid mechanics: Equation of continuity, Euler's equation of motion and Bernoulli's equations, Wave motion, Navier-Stoke's equation of motion and its solution under simplified conditions.

Elasticity: Basic Theorems In Dynamic Elasticity, Representation of Seismic Sources, Elastic Waves From a Point Dislocation Source.

Reference

1. Akai, K. and Richards, P.G. *Quantitative Seismology*: Theory & Method, Vols I & II (1980), W.H. Freeman & Co., San Francisco.
2. Chatterjee, R. *Mathematical Theory of continuum Mechanics*, Narosa.
3. More, G.F. *Theory and Problems of continuum Machanics*, Schaum's Outline Series, Mc-Graw Hill
4. Iwan, W.E. (1974): *Applied Mechanics in Earth Quake Engineering*, AMD Vol. 8
5. Love, A. E. H., *Theory of Elasticity*, Dober Publication
6. Landou, L.D. and Lifeshitz, E.M., 1987, *Fluid Mechanics* (2nd edn) Translated from Russian by J.B. Sykes and W.H. Reil(Reprint 1989), Pergamon press, Oxford, New York.

SM 612: Stochastic Processes &Time Series Analysis 3-1-0-4

Preliminaries of probability distributions, Laplace transforms, Laplace transforms of probability distributions of random variables, Simple random walk, multidimensional random walk. Stationary processes, Martingales, Markov chains, Higher transition probability and its determinations, Sequence of chain-dependent trials, Classifications of States and chains, Stability of Markov chains with denumerable number of states, Reducible chains. Poisson Processes and its related distributions, generalization of Poisson processes, Birth and Death processes, Markov processes with discrete state space (Continuous time Markov chain), Erlang processes. Renewal processes, Renewal processes in continuous time, Renewal equation, Renewal reward processes.

- Signal as Functions and their Orthonormal representations
- Discrete Signal Theory
- Linear Systems
- Convolution theorem, Deconvolution and the filter characteristics
- Measures and characterization of Information

Reference:

1. Box, G.E.P. and Jenkins, G.M. (1976). *Time Series Analysis- Forecasting and Control*, Holden-day, San Francisco
2. Anderson, T.W. (1971) *The Statistical Analysis of Time Series*, Wiley, N.Y.

3. Brillinger, D.R. (1981): Time Series: Data Analysis and Theory, Holden Day, San Francisco.
4. Yule & Kendall , *An introduction to the Theory of Statistics*,
5. Basawa, I.V., Prakasa Rao, B.L.S., *Statistical Inference for Stochastic Processes*, Academic Press (London), 1980

SM 613: Physics of the Earth and Geodynamics 3-1-0-4

- Outline of Plate Tectonics
- Analysis of bending of thin plates (Analog Lithosphere) under various loads such as iron change, sedimentary basins, subduction.
- Heat loss by the Earth: Mechanism; One dimensional conduction heat equation, an application to Lithosphere cooling, Geothermal gradient and Claussius- Clapeyoron, Geotherm- Clapeyorn curves.
- Gravitational Potential and Field; Gravity Anomaly and their calculations, Geochemical significance.
- Thermal Convection; Analysis of thermal conduction, in fluid layer under similar condition (Analog to mantle conduction)
- Elastic after-working; Simple problems on diffusion and dislocation in shear flows of fluids.

Reference:

1. Gubbins, D. (1990): Seismology and Plate Tectonics, Cambridge University Press, Cambridge
2. Dziewonski, A.M. and E. Boschi eds (1980) : Physics of the Earth's Interior, North Holland, Amsterdam
3. Kearey, P. and F.J. Vine (1990): Global Techtonics, Cambridge University Press, Cambridge
4. Lomnitz, C. (1994): Fundamental of Earthquake Prediction, John Wiley, New York
5. Frank Scherbaum (1996): *Fundamentals of Digital Seismology*, Kluwer Academic Publishers, The Netherlands.
6. Peter Shearer, *Introduction to Seismology*; Cambridge University Press.
7. Aki, K & Richards, P.G. (1980); *Qualitative Seismology*, Theory & Methods; W.H. Freeman.
8. Lay & Wallace: *Modern Global Seismology*. B.L.N. Kenneth (Vol 1&2)
9. Agustin Udias: *Principles of Seismology,* Cambridge University Press, Cambridge
10. David Gubbins: *Seismology and Plate tectonics,* Cambridge University Press, Cambridge.

SM 614: Computational Techniques and Programming 3-1-0-4

Structure of 'C' program, Data type in C, variable and constants in C. Arithmetic and logical expressions, increment and decrement operators, type conversion and type casting, standard input and output functions (scanf and printf); Control Statements, conditional statements, if ...else, Nesting of if…else, elseif ladder, switch statements, Loops in C: for, while, do…while loops, break, continue and exit (); Functions, classification of functions, functions definition and declaration, assessing a function, return statement, parameter passing techniques in C recursive function; Storage classes: Automatic variables, External variables, static variables, register variables, Scope and lifetime variables. Pointer declaration and Initialization: Accessing a variable through pointer, pointer expressions, pointer arithmetic, pointer comarition, pointer increment/ decrement and scale factor. Pointer and Array: Pointers and one dimensional arrays, dynamic memory allocation functions malloc and calloc, pointers and multidimensional arrays, arrays of pointers. Pointer and Functions: Pointers to pointers, pointers and functions, pointers to functions, function returning pointers, functions with variable number of arguments. Introduction to linked list, singly linked list, circular linked list linear linked list, node from list. Introduction to preprocessors, Macro substitution, Simple Macro Substitution, Macro with arguments, Nesting of Macros, Undefining a Macro, File inclusion, Conditional Compilation Directives

Standard header files, Library functions, Date and Time functions, variable argument list function, utility functions, character class test functions. (50 Theory +40 Laboratory hours besides the practical paper associated with this theory paper)

References

1. Balagurusamy, E: *Programming in ANSI C*, Tata McGraw Hill.
2. Kanetkar, Y.P.: *Working with C*, BPB publication
3. Gottfried, Byron S.: *Theory and problems of programming with C. TMH*
4. Schildt, Herbert: C: The complete reference III Ed.. TMH.
5. Schildt, Hebert: *C made easy*. McGraw Hill.
6. Garrido, J.M. (1998) Practical Process Simulation using Object Oriented Techniques and C++, Artech House, Boston, London
7. Barkakati, N. (1997) Object Oriented Programming in C++, Prentice Hall of India, New Delhi

SM 615: Finite Element Methods and Numerical Techniques 3-1-0-4

The standard discrete system, Finite elements of an elastic continuum-displacement approach, Generalization of the finite element concepts-weighted residual and variational approaches. Element types: triangular, rectangular, quadrilateral, sector, curved, isoparametric elements and numerical integration. Automatic mesh generation schemes. Application to structural mechanics problems: plane stress and plane strains, Axisymmetric stress analysis, three dimensional stress analysis, bending of plates. Introduction to the use of FEM in steady state field problems-heat conduction, fluid flow and non-linear material problems, plasticity, creep etc. Computer procedures for Finite element analysis.

Revision of numerical interpolation, differentiation and integration, least squares approximation, Gaussian methods and Gauss – Siedel iteration method for solving system of linear equations, computation of eigenvalues and eigenvectors of metrices by iteration methods, Gaussian quadrature, Numerical solutions of initial value problems using Runge Kutta methods, multistep methods, finite difference methods, boundary value problems using finite difference methods and shooting method,

Finite difference discretization – Truncation error, stability, consistency and convergence, Lax equivalence theorem (statement only). Finite difference treatment of 2nd order nonlinear partial differential equations of elliptic type, irregular boundary shapes and body fitted grid generation. Convergence. Acceleration of convergence, approximate factorization method, multigrid method Second order equations of parabolic type – ADI method, implicit schemes. Solution of hyperbolic system of conservation law computation of discontinuous solution. Introduction to finite volume method with simple examples.

Reference:

1. Cook: Finite element modeling for stress

SM 621: Mathematical Methods in Seismology 3-1-0-4

Green's functions , Special functions : Second order differential equations : Self adjoint operators ; Green's functions ; The Sturm-Liouville problem ; Fuchsian equation ;

Hypergeometric functions ; Functions related to Hypergometric function-Jacobi , Gegenbauer , Legendre ; Confluent Hypergeometric functions ; Functions related to Confluent Hypergeometric function-Hermite , Laguerre , Bessel .

Linear Vector Spaces : Real and complex vector spaces , metric spaces ; Linear Operators , algebra of linear operators ; Eigenvalues and eigenvectors ; Orthogonalisation theorem , N-dimensional vector space ; Tensors and tensor calculus ; Invariant subspaces , Cayley-Hamilton theorem ; Diagonalisation of Hermitian matrices , quadratic forms .

Function spaces , Orthogonal polynomials , Fourier Analysis : Space of continuous functions , metric properties of the space of continuous functions; Lebesgue integral ; The Riesz-Fischer theorem; Expansions in orthogonal functions; Hilbert space; Weierstrass theorem; Orthogonal polynomials-Rodriguez formula , recurrence relations , differential equations satisfied by classical polynomials; Fourier transforms-theory of generalized functions , Fourier transform of generalized functions.

Reference

1. C.D. Aliprantis & O Burkinshaw: *Principle of Real Analysis*, 3rd Edition, Harcourt Publisher, 1998.
2. H. L. Royden: *Real Analysis*, 3rd Edition, Prentice Hall of India, 1999.
3. G.Birktoff & G.C.Rote: *Ordinary differential equation*, John Wiely.
4. P.R.Halmos: *Finite Dimensional Vector Spaces*, Springer-Verlag, 1993.
5. Steven Roman: *Advanced Linear Algebra*, Springer-Verlag, 1995.
6. G. Arfken: *Mathematical Methods for Physicists*
7. Pipes & Harvill: *Applied Mathematics for Engineers & Physicists*, Tata McGraw Hill.

SM 622: Inverse Theory and Statistical Inference 3-1-0-4

Definition of inversion, Structure of problem. Elements of linear algebra and functional analysis. Generalized inverse. Singular value decomposition. Ridge regression and weighted ridge regression. Least square estimator. Over determined, underdetermined, ill posed and well posed problems. Local minimum and global minimum. Parameters statistics. Minimum length estimator. Bachus- Gilbert inversion. Stochastic inversion. Conjugate gradient minimization. Monte carle inversion. Occum inversion. Simulated annealing, Regularization. Tunneling algorithm. Nonlinear and two dimensional inversion. Joint and interactive inversion.

- Well-posed and ill posed problems; conditions for well posed problems.
- Basic form of Inverse Problems: Typical examples
- Linear Inverse Methods
- Non-linear Inverse Methods

Statistical Inference:-

- Sampling, Point Estimation & Interval Estimations
- Probability and Probability Distribution Models
- Hypothesis Testing & Analysis of Variance
- Bayesian Inference and Bayesian Theory

Reference:

1. Vogel, C.R.: *Computational Methods for Inverse Problems*. Vinayak Publications, Delhi 110095

SM 623: Computational Seismology 3-1-2-6

- Seismogram analysis, earthquake location, earthquake magnitudes 4+6
- Crustal structure studies 2+4
- Hypo-central location in complex media 4+2
- Earthquake source mechanism 2+2
- Generation of Synthetic Seismogram including strong motion, Inverse Modeling of Seismic Waveforms including modeling of Earthquake Sources, moment tensors 10+4
- Attenuation of seismic waves, Attenuation quality factor (Q) 4+2
- Seismic Imaging of the Earth's Interior (both Body and surface wave Tomography) 4+3
- Earthquake precursor, Computation of Earthquake Hazard, RIS, SWAM microzonation, 6+2
- Receiver function analysis 4+4
- Application of fractals in seismology 4+4

References

1. Telford, W.M. Geldart, L.P. and Sheriff, R.E., *Applied Geophysics*, Cambridge University Press, 1990.
2. Akai, K. and Richards, P.G. *Quantitative Seismology*: Theory & Method, Vols I & II (1980), W.H. Freeman & Co., San Francisco
3. Peter M. Shearer: *Introduction to Seismology*
4. Agustin Udias: *Principles of Seismology*
5. David Gubbins: *Seismology and Plate tectonics*
6. Durk J. Doorndos (1988): *Seismological Algorithms*: Computational methods and Computer Programs: Academic press, Hercourt Brace, Jovanovich, Publishers, London NWI, 469 pp.

SM 610: Computational Laboratory I (Semester I) 0-0-5-5
SM 620: Computational Laboratory I I (Semester II) 0-0-6-6

SM 631: Computer Graphics and Visualization (Elective) 3-1-0-4

Raster graphics and volume graphics: Video basics: Display devices and interactive devices; 2-D and 3-D graphics primitives. Clipping in 2-D and 3-D; Generation and projection of 3-D wire frame solid models, polygonal models. Space curves and surface models. Intersection of surfaces and blending; hidden line and hidden surface elimination algorithms; Ray-surface intersection and inverse mapping algorithms. Ray tracing for photo realistic rendering. Illumination models. Shading, Transparency, Shadowing and Texture mapping; Representation of colours.

Visualization of experimental and simulated data: Surface construction from scattered data, 3-D data arrays and 2-D cross sections. Elevation maps, topological maps, contour maps and intensity maps; fractals for visualization of complex and large data sets. Algebraic stochastic and Geometric fractals. Modeling of natural forms and textures using fractals; Visualization of multi variate relations. Flow visualization and hyper streamlines; Visualization of Meteorological, cosmological, seismic, biological data for scientific decision making.

Animation: Modeling issues in dynamic visualization. Behavioural animation; walk through – coordinate transformation and view transformation; virtual reality interfaces. Interactive and immersive systems for Prototyping and visualization; Visualization in concurrent engineering. Interactive multimedia technology and standards for Video-Graphics-Audio integration and tele-video conferencing.

Reference:

1. Wolfram, S. *Mathematica*: A system for Doing Mathematics by Computer, Addison Wesley, 1988.

SM 632: Pattern Recognition in Geo-sciences (Elective) 3-1-0-4

An overview of Applications of pattern recognition and image processing techniques.
Image processing: Seismic image processing – Hough transformation, Thinning processing and Linking processing; Image coding.

Pattern recognition applications: Seismic indicators and detection of bright spots; Decision rules for seismic classification; Detailed model inversion; Interactive pattern analysis and application of clustering in exploration seismology.

Artificial intelligence and expert systems for seismic data: Image processing and knowledge based methods for segmentation of a seismic section based on signal character; Expert systems for establishing hydrocarbon prospects using statistical pattern recognition.

Fuzzy sets and non-seismic applications: Improvement of seismic prospecting by using fuzzy subset theory; An example of the use of Fuzzy set based pattern recognition approach to the problem of strata recognition from drilling response; Pigeonholes and Petrography.

Reference

1. Duda, R.O. and P.E. Hart, (1973): *Pattern classification and Scene Analysis*, Wiley, New York,
2. Tou, J.T. and Gonzalez, R.C. (1974): *Pattern Recognition Principles*, Addison Wesley, Reading, M.A..

SM 635 Advances in Seismology: (Elective) 3-1-0-4

Earthquake source: Earthquake source mechanisms. Review of moment tensors. Seismic inversion problem for a flat structure. Strong motion seismology. Reservoir- Induced earthquakes.
Prediction of Strong ground motion: A theoretical study of the dependence of the Peak Ground Acceleration on source and structure parameters. High frequency earthquake strong ground motion in laterally varying media and the effect of fault zone. Physical mechanisms contributing to the seismic attenuation in the crust. Dynamic fracture mechanics. Near-field and far-field ground motions.
Strong motion data: Data acquisition and processing in strong motion seismology. Array analysis and synthesis mapping of strong seismic motion. Accelerogram spectral properties and prediction of peak values. Statistical model for peak ground motion from local to regional distances. Seismic intensity and its applications to engineering: a few case studies from Japan and Turkey.
Complete strong motion synthetics: Numerical modeling of realistic fault rupture processes: Kinematic dislocation models, 3-D modeling of spontaneous fault rupture processes. Stochastic simulation of high frequency ground motions based on seismological models of radiated spectra. Use of random vibration theory to predict peak amplitudes of transient signals. SHAKE'91. Fault surface integral and techniques for earthquake ground motion calculation with applications to source parameterization to finite faults. Path effects in strong motion seismology.

Hazard Assessment: Probabilistic models for assessment of strong ground motion. Seismic source regionalization. Seismic risk and its estimation.

Site response and engineering application: Site response analysis using classical spectral ratio, generalized inverse technique, horizontal-to-vertical spectral ratio or receiver function, network average and Nakamura ratio. Determination of in-situ shear-wave velocity and Q-factor. Site amplification and its relation to surficial geologic condition. Constitutive relationships for soil dynamics. Soil structure interaction effects on strong ground motion. Engineering uses of strong motion data and seismic microzonation.

References

1. Frank Scherbaum (1996): *Fundamentals of Digital Seismology*, Kluwer Academic Publishers, The Netherlands.
2. Peter Shearer, *Introduction to Seismology*; Cambridge University Press.
3. Aki, K & Richards, P.G. (1980); *Qualitative Seismology*, Theory & Methods; W.H. Freeman.
4. Durk J. Doorndos (1988): *Seismological Algorithms*: Computational methods and Computer Programs: Academic press, Hercourt Brace, Jovanovich, Publishers, London NWI, 469 pp.
5. Lay & Wallace: *Modern Global Seismology*. B.L.N. Kenneth (Vol 1&2)
6. Agustin Udias: *Principles of Seismology,* Cambridge University Press, Cambridge
7. David Gubbins: *Seismology and Plate tectonics,* Cambridge University Press, Cambridge
8. Gubbins, D. (1990): Seismology and Plate Tectonics, Cambridge University Press, Cambridge
9. Dziewonski, A.M. and E. Boschi eds (1980) Physics of the Earth's Interior North Holland, Amsterdam
10. Kearey, P. and F.J. Vine (1990) Global Techtonics, Cambridge University Press, Cambridge
11. Lomnitz, C. (1994) Fundamental of Earthquake Prediction, John Wiley, New York

SM 637: Structural Dynamics & Earthquake Engineering (Elective) 3-1-0-4

Introduction, Seismic Risks and seismic hazards, cause and strength of earthquake, social and economic consequences, theory of dynamics and seismic response, the nature and attenuation of ground motion. Determination of site characteristics, local geology and soil condition, site investigation and soil test. Determination of design earthquake, response spectra and accelerograms as design earthquake, criteria for earthquake resistant design. Site response to earthquake, liquefaction of saturated cohesionless soils, seismic response of soil structure system, shallow foundation, pile foundation, foundation in liquefiable ground. A seismic design of earth retaining structures.

Reference

1. Gubbins, D. (1990): Seismology and Plate Tectonics, Cambridge University Press, Cambridge
2. Dziewonski, A.M. and E. Boschi eds (1980) Physics of the Earth's Interior, North Holland, Amsterdam
3. Kearey, P. and F.J. Vine (1990) Global Techtonics, Cambridge University Press, Cambridge
4. Lomnitz, C. (1994) Fundamental of Earthquake Prediction, John Wiley, New York

SM 638: Fuzzy Set Theory & Applications (Elective) 3-1-0-4

Fuzzy sets - basic definitions, α-level sets, convex fuzzy sets, basic operations on fuzzy sets, types of fuzzy sets, cartesian products, algebraic products, bounded sum and difference, t-conorms.

The extension principle - the Zadeh's extension principle, image and inverse image of fuzzy sets, fuzzy numbers, elements of fuzzy arithmetic.

Fuzzy relations and fuzzy graphs, composition of fuzzy relations, min-max composition and its properties, fuzzy equivalence relations, fuzzy relation equations.

Possibility theory - fuzzy measures, evidence theory, necessity measure, possibility measure, possibility distribution, possibility theory and fuzzy sets, possibility theory versus probability theory.

Fuzzy logic, fuzzy propositions, fuzzy quantifiers, linguistic variables, inference from conditional fuzzy propositions, compositional rule of inference.

Approximate reasoning - an overview of fuzzy expert systems, fuzzy implications and their selection, multi-conditional approximate reasoning, role of fuzzy relation equation.

An introduction to fuzzy control - fuzzy controllers, fuzzy rule base, fuzzy inference engine, fuzzification, defuzzification and the various defuzzification methods.

Decision making in fuzzy environment - individual decision making, multi-person decision making, multi-criteria decision making, multistage decision making, fuzzy ranking methods, fuzzy linear programming, fuzzy logic as a tool in soft computing.

General applications of fuzzy sets and fuzzy logic.

References:

1. H. J. Zimmermann(1991): *Fuzzy set theory and its Applications*, Allied publishers Ltd., New Delhi.
2. G. J. Klir and B. Yuan (1997): *Fuzzy Sets and Fuzzy Logic : Theory and Applications*, Prentice Hall of India, New Delhi.
3. J. Yen & R. Langari (1999): *Fuzzy Logic, Intelligence, Control & Information*, Pearson Education.

SM 639: Geo- informatics & Data Analysis **(Elective)** 3-1-0-4

Basic concepts of Geological and geophysical data with reference to geographical and 3D space; temporal spectrum of evolution of continents, plate tectonics perspectives Module: Basic concepts of geodesy and Global Positioning System

Data base systems with special emphasis on relational data base, design of database for storage of wide diversity of geological and geophysical data, data retrieval.
Geographical information system – fundamentals of vector and raster data and structures for storage and efficient retrieval, basic and advanced GIS functions, GIS as decision support system.

Probability theory and distribution functions, Fundamental concepts of regionalized variables and spatial data in micro and macro domains, concepts of spatial geostatistics, introduction to logistic regression, weight of evidence, fuzzy set theory and application to spatial data modeling.

Broad overview on reconstruction of the 4D architecture of the Earth through integration of diverse types of Earth Science data in both short and long run temporal perspectives, application to prediction of Earth Processes and exploration of Earth Resources, Future of Geoinformatics.

References:

1. J. Delaney, K.V. Niel (2007): Geographical Information Systems: An Introduction, Oxfrod University Press.
2. W. Torge (2001): Geodesy, Walter de Gruyter.
3. P. Longley, M.F. Goodchild, D.J. Maquire, D. W. Rhind (2005): Geographical Information Systems and Science, John Wiley and Sons.
4. D. I. Heywood, S. Cornelius and S. Carver (2006): An Introduction to Geographical Information System, 3rd Edition, Pearson Prentice Hall.

SM-640: M. Tech. Dissertation - I **(Semester III)** **0-0-0- 10**
SM-650: M. Tech. Dissertation - II **(Semester IV)** **0-0-0- 14**

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