SCHEME AND SYLLABUS
OF

M.Tech Programme in
Civil Engineering
(2013 Scheme)

with specialisation in
GEOINFORMATICS

University of Kerala

Thiruvananthapuram

M.Tech Programme

CIVIL ENGINEERING –GEOINFORMATICS
CURRICULUM AND SCHEME OF EXAMINATIONS
SEMESTER I

Code No.	Name of Subject	Credits	Hrs / week	End Sem Exam hours	Marks			Remarks
					Internal Continuous Assessment	End Semester Exam	Total	
CMA 1002	Applied Probability and Statistics	3	3	3	40	60	100	Of the 40 marks of internal assessment 25 marks for test and 15 marks for assignment. End sem exam is conducted by the University
CRC 1001	Photogrammetry and Remote Sensing	3	3	3	40	60	100	do
CRC 1002	Applied Geomorphology	3	3	3	40	60	100	do
CRC 1003	Data Acquisition in Geoinformatics	3	3	3	40	60	100	do
CRC 1004	Introduction to Geographic Information System	3	3	3	40	60	100	do
CHC 1003	Engineering Hydrology	3	3	3	40	60	100	do

CRC 1101	Geoinformatics Laboratory	1	2	-	100	-	100	No End Sem Examination
CRC 1102	Seminar	2	2	-	100	-	100	do
	TOTAL	21	22					7 Hours of Departmental Assistance work

SEMESTER II

Code No.	Name of Subject	Credits	Hrs / week	End Sem Exam hours	Marks			Remarks
					Internal Continuous Assessment	End Semester Exam	Total	
CRC 2001	Digital Image Processing	3	3	3	40	60	100	Of the 40 marks of internal assessment 25 marks for test and 15 marks for assignment. End sem exam is conducted by the University
CRC 2002	Advanced GIS	3	3	3	40	60	100	do
*	Stream Elective I	3	3	3	40	60	100	do
*	Stream Elective II	3	3	3	40	60	100	do
*	Department Elective	3	3	3	40	60	100	do
CCC 2000	Research Methodology	2	2	3	40	60	100	Of the 40 marks of internal assessment 25 marks for test and 15 marks for assignment. End Sem Exam is conducted by the Individual Institutions
CRC 2101	Digital Image Processing Laboratory	1	2	-	100		100	No End Sem Examination
CRC 2102	Thesis Preliminary-	2	2	-	100		100	do

	Part 1							
CRC 2103	Seminar	2	2	-	100		100	do
	TOTAL	22	23	---				6 hours of Departmental assistance work

*Students can select a subject from the subject listed under stream/department electives as advised by the course coordinator.

List of Stream Electives

Stream Elective I

CRE 2001 Geo Spatial Data Processing

CRE 2002 Urban Spatial Planning and Analysis

CRE 2003 Hydroinformatics

Stream Elective II

CRE 2004 Thermal and Microwave Remote Sensing

CRE 200 5 Remote Sensing and GIS for Environmental Engineering

CRE 2006 Geoinformatics in Transportation Engineering

CRE 2007 Satellite Oceanography

SEMESTER III

Code No.	Name of Subject	Credits	Hrs / week	End Sem Exam hours	Marks			Remarks
					Continuous Assessment	End Semester Exam	Total	
*	Stream Elective III	3	3	3	40	60	100	Of the 40 marks of internal assessment 25 marks for test and 15 marks for assignment. End Sem Exam is conducted by the Individual Institutions
*	Stream Elective IV	3	3	3	40	60	100	do
**	Non- Dept. (Interdisciplinary) Elective	3	3	3	40	60	100	do
CRC 3101	Thesis Preliminary- Part II	5	14	-	200		200	No End Sem Examination
	TOTAL	14	23					6 hours of Departmental assistance work

*Students can select a subject from the subjects listed under stream electives as advised by the course co ordinator.
**Students can select a subject from the subjects listed under interdisciplinary electives as advised by the course co ordinator.

List of Stream Electives

Stream Elective III		**Stream Elective IV**
CRE 3001	Digital Photogrammetry	CRE 3004 Digital Terrain Modelling
CRE 3002	Geoinformatics for Disaster Management	CRE 3005 Remote Sensing and GIS applications in Water Resources Engineering
CRE 3003	Advanced Techniques in Image Processing	CRE 3006 Application of Geoinformatics in Coastal Engineering

SEMESTER IV

Code No	Subject Name	Credits	Hrs/week	Marks					Remarks
				Continuous Assessment		University Exam		Total	
				Guide	Evaluation Committee	Thesis Evaluation	Viva Voce		
CRC 4101	Thesis	12	21	150	150	200*	100	600	*5 % of the evaluation mark is earmarked for Publication in journal/conference
	Total	12	21	150	150	200	100	600	8 hrs of departmental assistance work

List of Department Electives

1. CSD 2001 Design of Bridges
2. CHD 2001 Project Planning in Water Resources
3. CRD 2001 Geoinformatics in Civil Engineering
   (Students of Geoinformatics specialization are not allowed to choose CRD 2001 subject as the contents are dealt with in detail in the core papers)
4. CGD2001-Geoenvironment and landfill
5. CGD2003-Geoenvironment and landfill
6. CTD 2001 Soft Computing Tools for Engineering
7. CTD 2002 Regional Transportation Planning
8. CED 2001 Ecological Engineering
9. CED 2002 Air Pollution Control and Monitoring
10. CED 2003 Environmental Impact Assessment and Risk Analysis

List of Interdisciplinary Electives

1. CSI 3001 Finite Element Analysis
2. CSI 3002 Mechanics Of Composites
3. CHI 3001 Fuzzy Sets And Systems In Engineering
4. CRI 3001 Geoinformatics For Infrastructure Development
5. CGI 3001 Geotechnical Engineering For Infrastructure Projects
6. CTI 3001 Fundamentals Of Reliability Engineering
7. CEI 3001philosophy Of Technology
8. CEI 3002 Environmental Management
9. CEI 3003 Environment And Pollution

CMA 1002 Applied Probability and Statistics

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment: 40 Marks
End Semester Examination : 60 Marks

Course Objectives

- To teach about the probability and random variable of the various functions
- To understand statistical procedures for data analysis

Learning Outcomes

- To equip the students to make use of the statistical procedures in the modelling of data in their field of study.

Module I

Probability Distributions: Probability mass functions and probability density function, mean and variance. Binomial, Poisson, Exponential, Gamma, Lognormal and Normal distribution, Fitting of the distributions (brief overview only). Sampling Techniques: Simple random sampling, Stratified sampling, Systematic sampling, Sample size determination-application Statistical Inference: Intervals estimation, Confidence interval for mean, variance and regression coefficients. Sampling distribution, test of significance of (i) Mean (ii) Mean of two samples (iii)Proportions (iv) Variance (v) Two variance (vi) Two observed correlation coefficients(Fishers' z-transformation) (vii) Paired T-test (viii) Regression coefficients (ix) Chi-square test of goodness of fit, Skewness and Kurtosis tests.

Module II

Regression and Correlation: Linear regression and correlation, multiple correlations, multiple correlation co-efficient, standard error of estimate, curvilinear regression-applications Analysis of variance (i) Completely randomized designs (ii) Randomized block designs. Latin Squares, Grecco Latin square designs, Factorial experiments, Graphical presentation techniques.

Module III

Time Series Models: Components of time series – smoothing – measuring forecasting accuracy – testing of ARIMA models. Multivariate Analysis: Co-variance matrix- correlation matrix-multivariate normal density function- principal components- sample variation by principal components-principal components by graphs

References

1. Gupta S.C. and Kapoor V.K, Fundamentals of Mathematical Statistics, Sultan Chand and Sons, 1978.
2. Benjamin Jack R. and Comell C.Allin, Probability Statistics and Decision for Civil Engineers, Mc-Graw Hill, 1997
3. Richard A. Johnson, Miller and Freunds, Probability and Statistics for Engineers, Prentice Hall of India, 2007
4. Dallan E. Johnson, Applied multivariate methods for data analysis, Thomson & Duxbburg Press, Singapore, 2002
5. Jay L. Devore, Probability and statistics for Engineering and Sciences, Thomson and Duxbburg Press, Singapore, 2002
6. Richard A. Johnson and Dean W. Wichern, Applied multivariate statistical analysis, Pearson Education, 2002

Structure of the Question paper

There will be three questions from each module out of which two questions are to be answered by the students.

CRC 1001 Photogrammetry and Remote Sensing

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment: 40 Marks
End Semester Examination : 60 Marks

Course Objectives

- Introduce the concept of Photogrammetry and Remote Sensing
- Develop an understanding of the types and variety of remote sensing systems available
- Develop an appreciation for the importance of remotely sensed images and photogrammetric analysis in Civil Engineering

Learning Outcomes

- Students will acquire capability for quantitative assessment from aerial photographs
- Students will be in a position to understand various satellite images
- The course will help to develop ability for image interpretation and feature identification from satellite data

Module I

Photogrammetry: Geometric characteristics of aerial photographs; Ground coverage of aerial photographs; Vertical and Tilted Photographs - Photographic Scale, Photo coordinates and Ground co-ordinates, Relief displacement, Tilt distortion. Stereoscopy & Image Parallax: Ground coordinates and Object height from parallax measurement; Mapping with aerial photographs - Ground control for aerial photography; Flight planning; Radial line method, Orthophotos; Introduction to Digital Photogrammetry.

Module II

Remote Sensing: Energy sources and radiation principles; Interaction of EM energy with atmosphere and surface features, Spectral reflectance patterns; Energy recording, Image resolutions, Multistage remote sensing concept. Types of satellites, sensors, orbits, and data products; Multispectral remote sensing – Methods of scanning, Geometric characteristics of satellite images; Thermal remote sensing - Radiation principles, Interaction of thermal radiation with atmosphere and terrain elements, Radiometric calibration of thermal scanners; Microwave remote sensing - Side looking radar system, Synthetic aperture radar, Geometric characteristics of SLR images.

Module III

Image Interpretation: Elements of visual image interpretation - Image interpretation keys; Introduction to Digital Image processing. Applications of Remote Sensing: Land use and lad cover mapping, Geology and soil mapping, Terrain classification and evaluation, Water Resource applications, Urban and regional planning.

References

1. Lillesand T.M. and Kiefer R.W., Remote Sensing and Image Interpretation, John Wiley and Sons, 1979
2. Sabins F.F (Jr.), Remote Sensing : Principals and Interpretation, Freeman & Co., San Francisco, 1978

3. Colwel R.N. (Ed.), Manual of Remote Sensing, Vol. I & II, American Society of Photogrammetry and Remote Sensing, Falls Church, Va. ,1983
4. Moffit, Francis, Photogrammetry, 2nd Edn, International Textbook Co. Scranton, 1967
5. Paul, R.Wolf, Elements of Photogrammetry, McGraw-Hill Book Co., New York, 1974
6. Keith P.B., Thompson et al. (Ed.), Remote Sensing and Water Resources Management, American Water Resources Association, Urbana Illinois, 1973.
7. Schowengerdt, R. A.,Remote sensing, Models and Methods for image processing, Academic Press, 2009
8. Joseph, G., Fundamentals of Remote Sensing, Universities Press, 2003.
9. Kennie, T.J.M. and Matthews, M.C., Remote Sensing in Civil Engineering, Surrey University Press, 1985.
10. Mitchell, C.W: Terrain Evaluation, 1985.

Structure of the Question Paper

There will be three questions from each module out of which two questions are to be answered by the student.

CRC 1002 Applied Geomorphology

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objective

- Able to describe the morphology of the landscape and the major processes that form it in areas influenced by fluvial, glacial, coastal and semi arid systems.
- Describe major scientific ideas and theories about the development of landscape.

Learning outcome

- Ability to critically analyse geomorphological issues in a scientific context at local, regional and global scales.
- Use topographic maps, basic field techniques and other quantitative techniques to analyse landforms and processes of land formation.

Module I

Fundamental concepts of geomorphology - Geomorphic agents and processes. Weathering and soil formation; Recognition of weathering patterns – NNRMS code on soil types – NBSS SLUP. Mass Wasting and geomorphic significance.

Module II

Fluvial landforms; Stages of stream development; Drainage patterns and morphometric analysis; Specific landform features (Oxbows, Levees, Cut offs, Flood plains, Meanders, etc.) Coastal geomorphology; Development of costal landforms; Recent trends in bathymetry; Arid landforms; Stages of arid landform development; Landform features. Glacial landforms: Erosional and depositional landforms

Module III

Tectonic geomorphology; Tectonic landforms, plate tectonics and its relation to earthquakes; Lineaments; Geospatial technology in structural and tectonic mapping – Ground water potential zone mapping. Geospatial Technology in landform studies.

References:

1. Ahmad, E. Coastal Geomorphology of India, Orient Longman, New Delhi, 1972.
2. Holmes, A. Principles of Physical Geology, Ronald, New York, 1965.
3. King, C.A.M. Beaches and Coasts, Arnold, London, 1972.
4. Leopold, L., Wolmen, C. and Miller, J.P., Fluvial Processes in Geomorphology, Freeman, 1963
5. Thornbury, W.D. Principles of Geomorphology, Wiley, 1968.
6. Li Deren Shan, Jie Gong, Jianya (Eds.), Geospatial Technologies for Earth Observation, 1st Edition, 2009
7. James L. A., Bishop M. P., and Walsh S. J., (Eds.), Geospatial Technologies and Geomorphological Mapping, Proceedings of the 41st Annual Bingamton Geomorphology Symposium, 2012, 137 (1)

Structure of the Question paper

There will be three questions from each module out of which two questions are to be answered by the students.

CRC 1003 Data Acquisition in Geoinformatics

Structure of the Course

Lecture : 3 hrs/ Week Credits : 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives

- To study about the modern survey equipments and their use in precision surveying.
- The ability to apply different data acquisition methods such as Total Station survey, GPS etc. for field problems

Learning Outcomes

- Understand the principles of various modern survey methods
- Understand the concept of surveying using total station and GPS

Module I

Introduction to Geomatics - Modern electronic survey measurements- Use and principle of automatic and digital levels, electronic theodolites, total stations- Field procedure for total stations in topographic survey- overview of computerized survey measurements- EDM

Module II

Satellite Navigational Systems-**Global Positioning Systems:** (NAVSTAR, GLONASS, GALILEO)-Basic concept of GPS: pseudo range and carrier phase measurements, signal structure, etc.-GPS coordinate systems: GPS time; GPS Errors and biases; GPS orbital Geometry and Navigational solution; Position measurements – Continuous Operating Reference stations (CORS)

Module III

Surveying with GPS: Planning and field observations; Data post-processing; GIS and GPS integration; Map concepts, co-ordinates and Map projection-Control surveys using GPS, Total station and triangulation methods (adjustment and computations of coordinates); Cartography and report writing-DGPS.

References:

1. Hoffman-Wellenhof B, H.Lichtenegger, J. Collins, GPS theory and Practice, Springer, 2000
2. Wells D.E., Guide to GPS Positioning, Canadian GPS Association, 1988
3. Anderle R., The Global Positioning System, Royal Society of London, U.K., 1995
4. Kennedy M, Global Positioning System and GIS: Introduction, Ann Arbor Press, 1996
5. Sickle J.V., GPS for Land Surveyors, Ann Arbor Press, Chelsea, 1996
6. Satheesh Gopi, R. Sathikumar, N Madhu, Advanced surveying Total Station, GIS and Remote sensing, Pearson Education, 2007

Structure of the Question paper

There will be three questions from each module out of which two questions are to be answered by the students.

CRC1004 Introduction to Geographic Information System

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objective

- Expose the students with the concept of GIS
- To provide exposure to data models and data structure used in GIS
- To introduce various Raster and Vector Analysis capabilities of GIS

Learning outcome

- The ability to understand various components of GIS
- The ability to do analysis of data using GIS
- The ability to prepare GIS output maps

Module I

Introduction to GIS: Geographical concepts and terminology, Components of GIS, Various GIS packages and their salient features, Applications of GIS. Types of Geo-Spatial Data: **S**patial and non-spatial data, Vector and raster data, Primary and secondary data, Characteristics and sources of spatial data, attribute data. Coordinate Systems: Geographic coordinate systems-approximations of earth, ellipsoid and geoid models, Datum-geodetic and vertical, coordinate transformation, Map projections-concepts and properties, classification, common map projections, examples of ellipsoids, UTM coordinate system. Raster and vector data models: Data organisation in a computer, Database Management systems, Relational DBMS, Raster data model- nature and elements, types, data compression, quad tree data representation, Vector data representation- nature and characteristics, topological maps and relationships, geo relational data model, object oriented geospatial data representation, Data conversion, Raster versus vector, Data models for composite features-TIN, regions, routes

Module II

Data input and editing: Methods of data input, File formats of raster data, Vector data input-map digitizing procedures, topology building. Geometric transformation- map to map and image to map transformations, transformation methods, Affine transformation, RMS error, Resampling, pyramiding, raster data editing, mosaicking, Spatial data editing- errors, topological and non topological editing, Attribute data input and management-type of attribute data, Relational model, normalisation, types of relationships, attribute data entry. Geospatial Data quality and standards: Data quality-accuracy, precision, errors, uncertainty, sources of errors, components and assessment of data quality, managing errors, Data standards- classification of standards in GIS, components, international geospatial data standards.

Module III

Data exploration and analysis: Data exploration- descriptive statistics, graphics, attribute data and spatial data query, map manipulation. Vector data analysis-buffering, overlay, slivers, distance measurement, pattern analysis, network based geo processing, Raster data analysis-

categories, Local operations-reclassification, overlay analysis, Operations on local neighbourhood- spatial aggregation, filtering, slopes and aspects, Operations on extended neighbourhood-statistical analysis, distance, proximity, connectivity, buffering, view shed analysis, Operations on regions, Map algebra-concepts. Data visualization: cartographic symbolization, types of maps, map design, map production.

References

1. Burrough P.P. & McDonnel, R.A. Principles of GIS, Oxford University Press, 1998
2. Chang, K , Introduction to Geographic Information Systems, Tata McGraw-Hill, 2008
3. Panigrahi,N, Geographical Information Science, University Press, 2008
4. Davis, B. E., GIS: A visual approach, Onword Press, 2001
5. Lo, C. P. And Yeung K.W., Concepts and Techniques in Geographic Information Systems, Second Edition, Pearson Prentice Hall, 2007
6. M Anji Reddy, Remote Sensing and Geographic Information Systems, B S Publications, Hyderabad, 2001
7. Heywood, I., Cornelius, S., Carver,S., and Raju, S. An Introduction to Geographic Information Systems, Pearson Education, 2007

Structure of the Question paper

There will be three questions from each module out of which two questions are to be answered by the students.

CHC 1003 Engineering Hydrology

Structure of the Course

Lecture : 3hrs/week Credits : 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives

- A good understanding of all the components of hydrologic cycle
- To understand the mechanics of rainfall, its spatial and temporal distribution.
- To understand the fitting of probability distribution and statistical analysis of rainfall and runoff.
- To understand the real time data monitoring and management system.

Learning Outcomes

- To understand the principles and applications of engineering hydrology.
- Provide the students with the tools for analysis, management and simulation used for the design of hydrologic systems.
- Understand the modeling of the rainfall runoff process.

Module I

Review: Hydrologic cycle, precipitation - types, time and spatial distribution of precipitation, Graphical representation of rainfall - Estimation of missing rainfall data - Test for consistency of rainfall records - probable maximum precipitation - Analysis of rainfall data - correlation between intensity and duration – intensity, duration and frequency - depth area duration (DAD) curve. Hydrologic abstractions (Brief description only) - Infiltration- Green-Ampt, Richard's and Philip's equations for infiltration estimation, Evapotranspiration - modified Penman equation - FAO method – real time data collection.

Module II

Catchment characteristics - stream patterns - stream order - classification of streams - stream flow measurement - Mid section method and mean section method - stage discharge rating curve - Extension of stage discharge curve - Adjustment of stage discharge curve - Runoff- Computation of runoff by curve number method - Rational method - S-hydrograph, synthetic unit hydrograph, concept of IUH - Derivation of IUH using S-curve, convolution integral, and conceptual models - linear reservoir - linear channel - rainfall runoff correlation using linear regression and multiple regression analysis.

Module III

Floods: Estimation of floods - methods, Flood frequency studies - Probabilistic method - Gumbel's method - Stochastic method - Annual duration series and partial duration series, Design flood and design storm. Flood routing: Flood routing through reservoirs - ISD method - Modified Pulse method. Flood routing through channels - Muskingum method - Flood control methods - flood control reservoirs - retarding basins - construction of levees - channel improvement-soil conservation methods - Flood forecasting and warning - real time monitoring system

References

1. Warren Viesmann Jr. and Gary L Lewis, Introduction to Hydrology, Prentice Hall, 2002
2. Chow.V.T. & Maidment R D, Handbook of Applied Hydrology, Mc Graw Hill Education 1988
3. Subramanya.K, Engineering Hydrology, Mc Graw Hill Education, 1984

4. Reghunath.H.M., Hydrology, New Age International (P) Limited, Publishers, 1987
5. Linsley .R.K, Kohler.M.A & Palhus.J.L, Applied Hydrology, Mc Graw Hill, 1949
6. Jayarami Reddy.P, A text book of Hydrology, Laxmi publications, 2005
7. Ghanshyam Das, Hydrology and soil conservation Engineering, Prentice-hall of India, NewDelhi, 2004

Structure of the Question Paper

For the End Semester Exam, there will be three questions from each module out of which two questions are to be answered by the students.

CRC 1101 Geoinformatics Laboratory

Structure of the Course

Practical: 2 hrs/ Week Credits: 1

Continuous Internal Assessment: 100 Marks

Course Objective

- To familiarise the students with maps and map reading
- To understand reading concepts of photogrammetry and GIS with practical experiments

Learning outcome

- The ability to understand maps
- The ability to apply photogrammetry and GIS concepts to practice

Exercise problems on:

SOI Toposheets

Map reading

Watershed delineation

Introduction to Remote Sensing data products

Different types of images

Visual image interpretation with 9 key elements

Generation of maps

Photogrammetry

Stereoscopy- practice and stereo model

Relief displacement and elevation

Orientation of stereo photographs

Parallax bar- practice and measurements

Heights from parallax measurements

GIS

Data import/ Export

Georeferencing

Digitization

Adding attribute data

DEM generation

Vector analysis - buffering, overlay and network analysis

Raster analysis-Arithmetic overlaying and logical overlaying

(Practice using ARC GIS software)

Data output, customization and scripting

Generation of maps

Introduction to various GIS packages like Geomedia, GRAM ++, GRASS, ILWIS,

Open source GIS software, IGIS

Reference

1. American Society of Photogrammetry, Manual of Remote Sensing, (2^{nd} ed), 1983
2. Lillisand.T.M, and Kiefer, P.W., Remote Sensing and Image Interpretation, John Wiley & Sons, 1998
3. Moffit, H.F., and Edward, M.M., Photogrammetry, Harperand Row Publishers, 1980
4. Wolf.P.R., Elements of Photogrammetry, McGraw Hill books Co., 1974
5. NRSC Landuse Land cover manual

CRC 1102 **Seminar**

Structure of the Course

Duration: 2 hrs/ Week Credits: 2

Internal Continuous Assessment: 100 Marks

The student has to present a seminar in one of the current topics in the stream of specialization. The student will undertake a detailed study based on current published papers, journals, books on the chosen subject, present the seminar and submit seminar report.

Distribution of marks:

Seminar report : 40 marks

Presentation : 60 marks

CRC 2001 Digital Image Processing

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment: 40 Marks
End Semester Examination : 60 Marks

Course Objectives

- Introduce the concept of digital image acquisition, processing, display and analysis
- Develop an idea regarding the suitability of different satellite images for various applications
- Develop an understanding of potential applications of remotely sensed data, tools and techniques for natural resource management

Learning Outcomes

- Ability for enhancing and processing digital images
- Ability to understand the suitability of various satellite images
- Ability for feature identification and classification from satellite data

Module I

Satellite Images: Data collection, recording and handling, Data storage and formats, Data products. Image rectification and restoration: Geometric and Radiometric corrections, Noise removal; Image statistics, Histograms, and Scatter plots.

Module II

Image enhancement: Contrast enhancement; Spatial feature enhancement - Spatial filtering, Edge enhancement, Texture enhancement, Convolution, Morphological filters, Gradient filters, Box-filter algorithm, Image resolution pyramids Frequency transformation (Fourier transforms); Multi image manipulation - Multispectral band ratios and differencing, Principal component analysis, IHS transformation.

Module III

Image Classification: Supervised classification - Minimum distance to mean, Parallelepiped, Maximum likelihood, and Baye's methods; Unsupervised classification - Single pass and Iterative; Non parametric and parametric classifications, spatial segmental classification, sub pixel classification, ANN and Fuzzy approaches in image classification. Post classification smoothing - Evaluation of accuracy. Change detection, Data compression techniques, Data scaling.

References:

1. Robert A. Schowengerdt, Remote Sensing: Materials and Methods for Image processing, Academic Press: Elsevier, 2007
2. Duda R. O. and Hart P.E., Pattern Classification and Scene Analysis, John Wiley and Sons, N.Y., 1973.
3. Tou J. T. and Gonzalez R. C., Pattern Recognition Principles, Addison Wesly, 1974.
4. Swain P. H. and Davis S. M. (Ed.), Remote Sensing : The Quantitative Approach, McGraw-Hill Book Co., N., 1978.
5. Lillesand T. M. and Kiefer R. W., Remote Sensing and Image Interpretation, John Wiley and Sons, 1979

6. F.F Sabins(Jr.), Remote Sensing : Principles and Interpretation, Freeman & Co., San Francisco, 1978
7. Jensen R., Introductory Digital Image Processing: A Remote Sensing Perspective, Upper Saddle River, Prentice- Hall, 1996.
8. Mather M., Computer Processing of Remotely Sensed Images : An Introduction, New York, John Wiley and Sons., 1988

Structure of the Question paper

There will be three questions from each module out of which two questions are to be answered by the students.

CRC 2002 ADVANCED G I S

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment: 40 Marks
End Semester Examination : 60 Marks

Course Objective

- Expose the students with advanced concepts of GIS
- To provide exposure to terrain modelling and analysis
- To introduce modern trends such as web GIS, customisation etc.

Learning outcomes

- The ability to select suitable interpolation techniques
- The ability to do terrain analysis
- Understand and do GIS customisation, programming

Module I

Spatial interpolation: Definition and necessity, methods of interpolation, Global interpolation-classification models, regression methods, trend surface analysis, Local interpolation-nearest neighbours, density estimation, inverse distance weighting, splines, comparison of interpolation methods, Optimal interpolation using geostatistics- regionalised variable theory, variogram models, ordinary kriging, block kriging, nonlinear kriging, probabilistic kriging

Module II

Terrain mapping and analysis: Digital Elevation models- methods of representation, TIN, DEM, conversion of TIN to altitude matrix and vice versa, characteristics of TIN and DEM, Delaunay triangulation, Terrain mapping-contouring, vertical profiling, hill shading, slope and aspect-computing algorithms for raster and TIN, surface curvature. View sheds and watersheds: View shed analysis- parameters, applications, Watershed analysis- operations to delineate watersheds and to derive features such as stream network, applications. Path analysis and network applications: Path analysis- cost distance measures, least cost accumulative path, applications, Network- geometry and attribute data of road network, putting together, Applications - shortest path analysis, allocation.

Module III

GIS modelling: basic steps in GIS modelling, designing a data model, cartographic modelling, project management, implementation problem, Case study- optimum route for hazardous materials transportation. GIS applications: GIS applications, railway route alignment, electricity distribution management system, tourism information system using WEBGIS. Web mapping with open source tool kits: Introduction to digital mapping - Merits and demerits of web mapping - Different kinds of web mapping - Map Server - Geospatial Data Abstraction Library - Open source tool kits. GIS customisation programming: GIS Customisation - Needs – Scripting Language – Advantage of Macro Scripting – Sample Case studies.

References

1. Burrough P.P. & McDonnel, R.A. Principles of GIS, Oxford University Press, 1998
2. Chang, K, Introduction to Geographic Information Systems, Tata McGraw-Hill, 2008

3. Panigrahi,N, Geographical Information Science, University Press, 2008
4. Davis, B. E., GIS: A visual approach, Onword Press, 2001
5. Lo, C. P. And Yeung K.W., Concepts and Techniques in Geographic Information Systems, Second Edition, Pearson Prentice Hall, 2007
6. M Anji Reddy, Remote Sensing and Geographic Information Systems, B S Publications, Hyderabad, 2001
7. Heywood, I., Cornelius, S., Carver, S., and Raju, S. An Introduction to Geographic Information Systems, Pearson Education, 2007
8. Li, S., Dragicevic, S., and Veenendaal, B., Advances in web-based GIS, mapping services and applications, CRC Press, 2011
9. Yang, C., Advanced geo information Science, CRC Press, 2011

Structure of the Question paper

There will be three questions from each module out of which two questions are to be answered by the students.

CRE 2001 Geo Spatial Data Processing

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment: 40 Marks
End Semester Examination : 60 Marks

Course Objective

- To provide students an introduction to principles and techniques of data base design and development as they apply to geospatial data.
- To familiarize the principles and techniques in designing and building geospatial data bases
- To introduce the concept of Mobile mapping and Web GIS

Learning outcome

- Ability to create, edit and document geospatial datasets
- Ability to develop and document a conceptual design of a geospatial database for a specific application problem
- Ability to develop custom build GIS applications

Module I

Spatial data acquisition and development: Observations and mathematical model, precision and accuracy, rejection of observations, weights and cofactors, correlation and covariance, propagation of errors and variance-covariance.

Module II

Spatial Data bases: characteristics, development, acquisition. Least squares adjustment computations; Sequential processing and Kalman Filtering; Variance-covariance of adjusted data, error ellipse and error ellipsoid; Statistical analysis of adjusted data.

Module III

GIS customization concepts, Role of programming languages in GIS customization. Introduction to Visual Basic Programming Language. Overview of internet GIS, Internet GIS, Development with open source and other softwares. Fundamentals of Mobile Mapping, Mobile mapping applications

References

1. Kraak M. and F. Omerling, Visualization of Geo Spatial data, Pearson education, delhi, 2003
2. Kraak M. and A. Brown, Web Cartography: Development and Prospects, Taylor and Francies, London,2001
3. Robert A.Schowengerdt, Remote Sensing: Materials and Methods for Image processing, Academic Press: Elsevier, 2007

4. Zeiler Michael, Modeling Our World, The ESRI Guide to Geo Data Base Design, Environmental Systems Research Institute, Inc., Red Lands, California. USA- 2002
5. Zong R Peng, Ming H Tsou, Internet GIS Distributed Geographic Information Services for Internet and Wireless Network, John Wiley and Sons, 2003
6. Juliano Lopes de Olivera, Claudia Bauzer Medeiros, Mariano Cilia, “Active Customization of GIS User Interfaces” , ICDE '97 , Proceedings of the Thirteenth International Conference on Data Engineering
7. C. V. Tao and J. Li, Advances in Mobile Mapping Technology, Taylor and Francis, 2007
8. Arc Objects Developer Guide, ESRI, 2001

Structure of the Question paper

There will be three questions from each module out of which two questions are to be answered by the students.

CRE 2002 **Urban Spatial Planning and Analysis**

Structure of the Course

Lecture : 3 hrs/ Week Credits : 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives

- To equip the students for the effective planning and design of urban systems using spatial modeling

Learning Outcomes

- To understand the concepts used for urban mapping including transportation planning.
- To inculcate the preparation of maps for different spatial analysis carried for urban planning and transportation planning with the aid of remote sensing and GIS

Module I

Introduction : Remote sensing for detection of urban features – Scale and resolution – Scope and limitations – Interpretation from Aerial and satellite images – Digital image processing techniques – Image fusion – Case studies. Settlement Mapping : Classification and settlement – settlement structure – Segmentation of Built-up areas – Classification algorithms – Land use/ Land cover mapping – change detection – high resolution remote sensing – case studies.

Module II

Analysis and planning : Urban morphology – Housing typology – Population estimation from remote sensing – Infrastructure demand analysis – Urban renewal Land suitability analysis – Plan formulation – Regional, Master and detailed development – Use of remote sensing and GIS in plan preparation – Urban information system – Web GIS – case studies.

Module III

Transportation planning : Mapping transportation network – Classification – Optimum route/ shortest route – Alignment planning – Traffic and parking studies – Accident analysis – case studies. Current trends : Urban growth modeling – Expert systems in planning – 3D city models – ALTM – Land use Transportation interaction models – Intelligent transportation systems – case studies

References

1. Tony Kendle and Stephen Forbes, Urban Conservation – Landscape Management in Urban country Side , E & FN SPON, London, 1997.
2. The Royal Commission on Environmental Pollution Report – Transport and Environment, Oxford University Press, 1995.
3. Rob Gray , Accounting for the Environment, Chartered Association of Certified Accountants, 1003.
4. Richard Kelly, Stuart Barr, Spatial modeling of Terrestrial Environment, John Wiley, 2004
5. Barnsley M. J., Donnay J. P., Remote Sensing and Urban Analysis, Taylor and Francis,2000
6. Stewart F. Michael W., Spatial Models and GIS: New Potential and New Models, Taylor and Francis, 1999
7. Manual on Urban Spatial Planning, NRSC, 2006

Structure of the Question paper

There will be three questions from each module out of which two questions are to be answered by the students.

CRE 2003 **Hydroinformatics**

Structure of the course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives

- Aimed at introducing the techniques and tools developed in information technology for rapid hydrological information analysis and modeling.
- To illustrate the concepts of soft computing techniques for modeling of hydroinformatics.

Learning Outcomes

- Ability to integrate hydrologic and GIS models
- To understand the different data integrative approaches in computation, analysis and modelling in hydroinformatics

Module I

Hydrologic Data Models : Data models - geodata model - structure of Geodatabase - Arc Hydro data model. UML-frame work, relationships, diagrams, object model diagrams- use in modeling applications.Modelshed Geodata model – structure - modeling of fluxes, modelshed links, area link, orthogonal link, Dynamic model shed links, area link, orthogonal link, Dynamic modelshed- features, applications.File format in data models- Programming model-application programming interfaces-concept of data file formats- file access, file structure.

Module II

Integration of Hydrologic and GIS models – coupling - loose and rigid type- Embedding types- Examples- case studies.Statistical data mining- supervised learning - regression methods- multivariable linear regression, Non-linear regression, tree based methods-classification trees- regression trees- Nearest neighbourhood methods – K nearest neighbourhood unsupervised learning- cluster analysis - Hierarchical clustering- K mean clustering.Genetic Algorithms- Concepts, GA basics, Selection, cross over, mutation, - Simple genetic algorithm, formulation concepts for unconstrained problems, Constraint Handling- application to Hydroinformatics problems

Module III

Artificial Neural networks- concept, architecture and types, transfer functions, training algorithms- Back propagation neural networks, RBF networks, Recurrent networks- Pruning techniques- application in hydroinformatics. Fuzzy Logic- Fuzzy set- Fuzziness Vs randomness- types of uncertainty- linguistic variables and inference rules – membership functions, basic operations- Fuzzy relation- max-min, max product composition - fuzzy reasoning – fuzzy logic model formulation – types, fuzzification, defuzification-Hydroinformatics application.

References

1. Han.J., and M.Kamber, Data Mining Concepts and Techniques, Morgan Kaufman, San Francisco, 2001
2. Praveen Kumar, Jay Alameda, Peter Bajcsy, Mike Folk and Momcilo Markus, Hydroinformatics :Data Integrative Approaches in Computation, Analysis and Modelling, Taylor and Francis, 2006
3. Goldberg, D.E., Genetic Algorithm in search, optimization and machine learning, Addison Wesley, 1999
4. Hertz, Krogh, Palmer, Introduction to the theory of Neural Computation, Addison Wesley, 1991.
5. Chin Teng Lin and George Lee, Neural Fuzzy Systems, Prentice Hall, 1995
6. Ross T J. Fuzzy logic with Engineering applications, Mc Graw Hill, 1995

Structure of the Question paper

There will be three questions from each module out of which two questions are to be answered by the students.

CRE 2004 Thermal and Microwave Remote Sensing

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives

- To cover the fundamentals of thermal and microwave remote sensing
- To provide a summary of the information needed for space based microwave remote sensing systems

Learning Outcomes

- Students will develop knowledge about the various thermal and microwave sensors operating in space
- Ability to apply thermal infrared models for various applications in the field of civil engineering
- Ability to use microwave data for the analysis of various problems in land and water.

Module I

Thermal remote sensing: Introduction, Radiation principles, Interaction of thermal radiation with atmosphere and terrain elements, thermal sensors and their characteristics, radiometric calibration of thermal scanners. Interpretation of thermal images - day and night images, emissivity consideration, thermal inertia considerations. Estimation of land surface temperature from thermal images. Application of thermal remote sensing data in crop health monitoring, pollution monitoring, oil spill detection, glaciology, atmospheric modelling, Sea Surface Temperature, PFZ.

Module II

Introduction to microwave remote sensing - active and passive systems, platforms and sensors. Passive microwave systems: mathematical formulation for microwave radiation and simulation, measurement and analysis of brightness temperature, applications in various fields - oceanography and meteorology. Active microwave systems: basic principles of radar, radar equation, resolution, range, phase and angular measurements, microwave scattering and its measurement, relationships between scene and sensor parameters. Imaging systems - Real Aperture radar (RAR) and Synthetic Aperture radar (SAR), Microwave radiometer, Microwave Scatterometer, Microwave altimeter.

Module III

SAR imagery - their characteristics and interpretation, applications in various fields—land use/land cover, soil/rock, hydrology. SAR interferometry for DEM generation, differential SAR interferometry for surface displacement studies, applications in land subsidence, landslide movements, glacier movements etc. Polarimetry in radar remote sensing, basic equations, propagation of waves and wave polarization. HH, VV, HV and VH polarization data and their applications.

References

1. Henderson, F.M. and Anthony, J.L., Principles and Applications of Imaging Radar, Manual of Remote Sensing, Vol. 2, John Wiley and Sons , 1998
2. Manual of Remote Sensing, Volumes 1 to 5, American Society of Photogrammetry and Remote Sensing, 2003
3. Schowengerdt, R.A., Remote Sensing Models and Methods in Image Processing, Academic Press, 2006
4. Ulaby,F.T.,Moore,K.R. and Fung, Microwave remote sensing vol-1,vol-2 and vol- Addison-Wesley Publishing Company,London,1986.
5. Philippe Lacomme,Jean clande Marchais,Jean-Philippe Hardarge and Eric Normant, Air and spaceborne radar systems-An introduction, Elsevier publications 2001.
6. Roger J Sullivan, Knovel, Radar foundations for Imaging and Advanced Concepts, SciTech Pub, 2004.
7. Woodhouse, I.H., Introduction to microwave remote sensing, Taylor and Francis, London, 2006.
8. Curlander J.C., and R.N. Mcdonough, Synthetic Aperture Radar, Systems And Signal Processing, John Wiley Sons Inc., New York, 1991
9. Elachi C, and F.T. Ulaby, Radar Polarimetry for Geoscience Applications, Artech House, Norwood, MA, 1990.
10. Mott, H., Remote sensing with polarimetric radar, John Wiley and Sons, New York, 2007.
11. Lee, J.S. and Pottier, E., Polarimetric Radar Imaging: From Basics to Applications, CRC Press, London, 2009

Structure of the Question paper

There will be three questions from each module out of which two questions are to be answered by the students.

CRE 2005 Remote Sensing and GIS for Environmental Engineering

Structure of the Course

Lecture : 3 hrs/ Week Credits : 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives

- To understand the various remote sensing and GIS technological applications in the field of Environmental Engineering.
- To understand the various satellites and data products that can act as aid in environmental modeling problems

Learning Outcomes

- Capability to make use of remote sensing and GIS data products for analyzing problems in environmental engineering
- Understand the concepts of incorporating spatial data in modeling of soil, water and air quality studies.

Module I

Introduction, Environmental satellites GEOS, NOAA, AVHRR, CZCR Monitoring land, water, atmosphere and ocean using Remote Sensing Data, case studies. Taxonomical classification of soils, soil survey interpretation and mapping, impact of agricultural and industrial activity on soil properties. soil salinity/alkalinity, erosion studies, Applications of GIS in assessing soil salinity, erosion productivity etc.

Module II

Water Quality and Ground Water Pollution : Classification of water quality for various purposes. Data base creation and quality modeling using GIS. Database Creation and maintaining water supply network, sewerage network using GIS. Case studies. Aquifer Vulnerability Intrinsic and specific vulnerability, DRASTIC, SINTACS MODELS MODFLOW, MT3D, contaminant transport model. Case studies.

Module III

Air Quality Modelling : Atmosphere: Chemicals, Particulate matters present in the atmosphere, allowable limits, Remote Sensing technique to monitor atmosphere constituents, air pollution due to industrial activity, modeling using GIS. Case Studies. Environmental Management : Revenue management-environment and ecological concerns- Resource development in remote areas-Impacts of anthropogenic activity- Solid Waste management-Carbon footprints and sinks, carbon trading, carbon credits and marketing, Indian and international status

References

1. Ian L. Pepper, Charles P.Gerbaand Mark L.Brusseau, Environmental and pollution science Academic Press, 2006.
2. Savigny.D De and Wijeyaratne .P GIS for Health and Environment, Stylus publication, 1994.

3. Reger D.Griffin, Air Quality Assessment and Management, Taylor and Francis, 2nd ed, 2006.
4. Donald L. Wise, Remediation for Hazardous waste contaminated soils, CRC Press, 1994.
5. George Tchobanoglous, Hilary Theisen, Samuel A. Vigil Integrated Solid Waste Management : Engineering Principles and Management Issues, Mc Graw Hill, 1993
6. Michele Campagna, GIS for sustainable development, CRC Press, 2005.

Structure of the Question paper

There will be three questions from each module out of which two questions are to be answered by the students.

CRE 2006 Geoinformatics in Transportation Engineering

Structure of the Course

Lecture : 3 hrs/ Week Credits : 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives

- To understand the basic concepts of Geoinformatics in the context of transportation and transportation networks.
- To learn the data needs and database development for doing transportation analysis in GIS environment.
- To understand the concepts of transportation networks and algorithms and how they are incorporated into GIS.

Learning Outcomes

- Students will acquire a basic understanding of how GIS processes can be used for efficient transportation modeling and analysis.
- Students will understand various applications of GIS in Transportation (GIS-T) including Intelligent Transport Systems (ITS)

Module I

Traffic Engineering Studies and Analysis: Objectives, Sampling in traffic studies, sample size; Data collection, analysis and interpretation -Spot speed, Speed and delay, Volume, Origin – destination, Parking. Concept of PCU, Factors affecting capacity and level of service, Types of manoeuvres and conflict points.

Module II

Transportation Planning using GIS- Travel Demand Estimation-Application of GIS, Traffic Analysis Zone (TAZ) and screen lines, Four Stage Planning Process (Brief description only), Network representation of a transportation System, Shortest Path determination, GIS based Transportation Planning, Spatial and Non spatial data for land use and transportation.

Module III

ITS: Introduction to Intelligent Transport System- Components of ITS, Application of ITS to Traffic Management System- Public Transportation Management System, Application of GIS in vehicle routing analysis and visualisations of traffic data in GIS, Integration of GPS and GIS, Travel time analysis using GPS-GIS integration. GIS-T applications: Scope of TransCAD and EMME in Transportation Planning (Introduction only)

Reference

1. Hensher D. A., Button K. J., Haynes K. E., and Stopher P. R. (Eds.), Handbook of Transport Geography and Spatial Systems", Elsevier,2004.
2. Thill Jean-Claude, Geographical Information Systems in Transportation Research, Pergamon, 2000.
3. Longley P. A., Barnsley M. J., Donnay Jean-Paul, Remote Sensing and Urban Analysis, Taylor & Francis, 2001.
4. Caliper Corporation, Travel Demand Modelling with TransCAD, 2009.
5. Hutchinson, B. G., Principles of Urban Transportation Planning, Mc Graw Hill, 1979
6. Kadiyali, L.R.Traffic Engineering and Transportation Planning, Khanna Publishers

Structure of the Question paper

There will be three questions from each module out of which two questions are to be answered by the students.

CRE 2007 Satellite Oceanography

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objective

- To provide a basic understanding in the fields of oceanography and ocean remote sensing.
- To provide a broad knowledge of the various techniques used in satellite and airborne remote sensing of the sea.
- To appreciate the applications of remote sensing to oceanographic studies.

Learning Outcome

- Students will obtain the basics of physical, chemical, and biological oceanography
- Gain information about the main systems observing ocean from space
- Develop some practical skills on using satellite data for the analysis of ocean ecosystem dynamics.

Module I

The basic concepts of oceanography: Physical, Chemical and Biological Oceanography, Hydrophysical processes in the ocean, external forces driving ocean currents - earth rotation and wind stress, heat flux through the ocean surface - temperature, salinity and density, role of stratification in phytoplankton ecology.

Module II

Remote sensing of the sea: The general principles of remote sensing of the sea, basic elements and sampling characteristics of satellite orbits, Electromagnetic spectrum and satellite sensors, sensor calibration, atmospheric correction, positional registration, Oceanographic sampling. The main types of sensors: Visible wavelength “ocean color” sensors, Infrared radiometers of sea surface temperature, Passive microwave radiometers, Active radar-altimeters of sea surface topography, Active microwave sensors of sea surface roughness.

Module III

Oceanographic Applications: Infrared Measurement of Sea Surface Temperature, Infrared radiometry, Interpretation of sea surface temperature. AVHRR, MSCSST algorithm, GEOS,
Radar altimeters: Basic principles of satellite altimetry, TOPEX/Poseidon satellite, Sea Surface Height, Sea Surface Roughness, Microwave scatterometer, Synthetic Aperture Radar
Ocean Color: satellite measurements of ocean color, Coastal Zone Color Scanner (CZCS), SeaWiFS, MODIS, ocean color dynamics in different ocean regions. Ocean Color and Phytoplankton Growth: Chlorophyll and photosynthesis, Estimation of phytoplankton biomass from Satellite Ocean color observations, Estimation of chlorophyll fluorescence from MODIS ocean color observations, Global phytoplankton biomass and primary production

References

1. Garrison, T., Oceanography: An Invitation to Marine Science 5th ed. Brooks., 2007
2. Gross, M. G., Principles of Oceanography", Prentice-Hall, 7th ed. 1995 .
3. Martin, S., An Introduction to Ocean Remote Sensing, Cambridge University Press, 2004.
4. Robinson, I., Measuring the oceans from space: the principles and methods of satellite oceanography, Springer, Berlin, 2004.
5. Robinson, I., Understanding Oceans from Space: The unique applications of Satellite Oceanography, Springer, Berlin,2004
6. Fu, L.L., Cazenave, A. Satellite altimetry and earth sciences. Academic Press, 2001.

Structure of the Question paper

There will be three questions from each module out of which two questions are to be answered by the students.

CRD2001 Geoinformatics in Civil Engineering

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment: 40 Marks
End Semester Examination : 60 Marks

Course Objectives

- Expose the students with concept of GIS and remote sensing.
- To provide exposure to the applications of GIS and Remote sensing in Civil engineering

Learning outcomes

- Understand the concepts of data acquisition and interpretation of satellite images
- Understand the capabilities GIS Techniques for spatial analysis and representation of data.
- Capability to make use of remote sensing data and GIS concepts for modeling of Civil Engineering problems.

Module I

Remote Sensing: Energy sources and radiation principles-Interaction of EM energy with atmosphere and surface features, spectral reflectance patterns, Classification of Remote sensing systems. Data acquisition and interpretation – Multistage remote sensing concept-multispectral, thermal and microwave remote sensing. Image Interpretation : Elements of visual image interpretation – Image interpretation keys – Image interpretation equipment - Introduction to Digital Image processing.

Module II

Introduction to GIS: Geographical concepts and terminology, Components of GIS, Various GIS packages and their salient features, Applications of GIS. Spatial and non-spatial data, Vector and raster data -Coordinate Systems: Geographic coordinate systems-approximations of earth, ellipsoid and geoid models, Datum-geodetic and vertical, coordinate transformation, Map projections-concepts and properties.Data input and editing: Methods of data input, Spatial data editing-Vector data analysis-buffering, overlay, slivers, Raster data analysis- categories. Data visualization: cartographic symbolization, types of maps, map design, map production

Module III

Applications: Landuse/land cover mapping, watershed analysis, water resources engineering, EIA, coastal engineering, Topographic mapping, Transportation Engg., Municipal solid waste management, Natural disaster management etc.

References

1. Lillesand T.M. and Kiefer R.W., Remote Sensing and Image Interpretation, John Wiley and Sons, 1979
2. Sabins F.F (Jr.), Remote Sensing : Principals and Interpretation, Freeman & Co., San Francisco, 1978

3. Colwel R.N. (Ed.), Manual of Remote Sensing, Vol. I & II, American Society of Photogrammetry and Remote Sensing, Falls Church, 1983
4. Moffit, Francis, Photogrammetry, 2nd Edn, International Textbook Co. Scranton, 1967
5. Paul, R.Wolf, Elements of Photogrammetry, McGraw-Hill Book Co., New York 1974
6. Keith P.B., Thompson et. Al. (Ed.), Remote Sensing and Water Resources Management, American Water Resources Association, Urbana Illinois, 1973.
7. Schowengerdt, R. A.,Remote sensing, Models and Methods for image processing, Academic Press,2009
8. Joseph, G., Fundamentals of Remote Sensing, Universities Press, 2003
9. Kennie, T.J.M. and Matthews, M.C., Remote Sensing in Civil Engineering, Surrey University Press, 1985
10. Burrough P.P. & McDonnel, R.A., Principles of GIS, Oxford University Press, 1998
11. Chang, K, Introduction to Geographic Information Systems, Tata McGraw-Hill, 2008
12. Panigrahi,N, Geographical Information Science, University Press, 2008
13. Davis, B. E., GIS: A visual approach, Onword Press, 2001
14. Lo, C.P. and Albert Yeung , Concepts and Techniques of GIS , Prentice Hall, 2nd Ed. 2006
15. M Anji Reddy, Remote Sensing and Geographic Information Systems, B S Publications, Hyderabad, 2001

Structure of the Question paper

There will be three questions from each module out of which two questions are to be answered by the students.

CCC 2000 **Research Methodology** **2-0-0-2**

Structure of the Course

Lecture : 2 hrs/ Week Credits : 2
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objective:

To formulate a viable research question
To distinguish probabilistic from deterministic explanations
To analyze the benefits and drawbacks of different methodologies
To understand how to prepare and execute a feasible research project

Outcome

Students are exposed to the research concepts in terms of identifying the research problem, collecting relevant data pertaining to the problem, to carry out the research and writing research papers/thesis/dissertation.

Module 1

Introduction to Research Methodology - Objectives and types of research: Motivation towards research - Research methods *vs.*Methodology. Type of research: Descriptive *vs.*Analytical, Applied *vs.* Fundamental, Quantitative *vs.* Qualitative, and Conceptual*vs.* Empirical. Research Formulation - Defining and formulating the research problem -Selecting the problem - Necessity of defining the problem - Importance of literature review in defining a problem. Literature review: Primary and secondary sources - reviews, treatise, monographs, patents.Web as a source: searching the web. Critical literature review - Identifying gap areas from literature review - Development of working hypothesis.

Module 2

Research design and methods: Research design - Basic Principles- Need forresearch design — Features of a good design. Important concepts relating to research design: Observation and Facts, Laws and Theories, Prediction and explanation, Induction, Deduction. Development of Models and research plans: Exploration, Description, Diagnosis, Experimentation and sample designs.Data Collection and analysis: Execution of the research - Observation and Collection of data - Methods of data collection - Sampling Methods- Data Processing and Analysis strategies - Data Analysis with Statistical Packages - Hypothesis-Testing -Generalization and Interpretation.

Module 3

Reporting and thesis writing - Structure and components of scientific reports -Types of report - Technical reports and thesis - Significance - Different steps in the preparation, Layout, structure and Language of typical reports, Illustrations and tables, Bibliography, referencing and footnotes.Presentation; Oral presentation - Planning - Preparation -Practice - Making presentation - Use of audio-visual aids - Importance of effective communication.

Application of results of research outcome: Environmental impacts –Professional ethics - Ethical issues -ethical committees.Commercialization of the work - Copy right - royalty - Intellectual property rights and patent law - Trade Related aspects of Intellectual Property Rights - Reproduction of published material - Plagiarism - Citation and acknowledgement - Reproducibility and accountability.

References:

1. C.R Kothari, Research Methodology, Sultan Chand & Sons, New Delhi,1990
2. Panneerselvam, “Research Methodology”, Prentice Hall of India, New Delhi, 2012.
3. J.W Bames,” Statistical Analysis for Engineers and Scientists”, McGraw Hill, New York.
4. Donald Cooper, “Business Research Methods”, Tata McGraw Hill, New Delhi.
5. Leedy P D, "Practical Research: Planning and Design", MacMillan Publishing Co.
6. Day R A, *"How to Write and Publish a Scientific Paper"*, Cambridge University Press, 1989.
7. Manna, Chakraborti, “Values and Ethics in Business Profession”, Prentice Hall of India, New Delhi, 2012.
8. Sople,” Managing Intellectual Property: The Strategic Imperative, Prentice Hall of India, New Delhi, 2012.

CRC 2101 Digital Image Processing Laboratory

Structure of the Course

Practical: 2 hrs/ Week Credits: 1
Continuous Internal Assessment: 100 Marks

Course Objective

- To familiarise the students with reading understanding various satellite images
- To understand the concept of different image processing techniques

Learning outcome

- The ability to understand different satellite images
- The ability to apply image processing techniques for deriving different thematic maps from satellite imagery

Exercise problems on:

Reading and displaying satellite data- generation of False Colour Composite (FCC)- Extracting area of interest (AOI)- generating Histogram of various bands. Image Pre-processing- Geometric corrections, radiometric corrections– merging and segmentation - noise removal. Image enhancement- contrast manipulation- spatial filtering-Edge enhancement. Multi image manipulation- spectral ratios- principal component analysis. Classification- supervised classification- unsupervised classification Accuracy assessment, Map composition (Practice using ERDAS Imagine and ILWIS software)

References

1 American Society of Photogrammetry, Manual of Remote Sensing, (2^{nd} ed), ASP, Falls Church, Virginia, 1983
2. Lillisand.T.M, and Kiefer, P.W., Remote Sensing And Image Interpretation, John Wiley & Sons, New York, 1998.
3. Burrough and McDonnel, Principles of Geographical Information System, Oxford University Press, 1998
4. Robert A.Schowengerdt, Remote Sensing: Materials and Methods for Image processing, Academic Press: Elsevier, 2007
5. NRSC Landuse Land cover manual

CRC 2102 **Thesis Preliminary (Part 1)**

Structure of the Course

Duration: 2 hrs/ Week Credits: 2

Continuous Internal Assessment: 100 Marks

The student is expected to start the preliminary background studies towards the Thesis by conducting literature survey in the relevant field. He/she should broadly identify the area of the Thesis work, familiarize with the design and simulation tools required for the thesis work and plan the experimental platform if any, required for the thesis work. The student will submit a detailed report of these activities at the end of the semester.

CRC 2103 **Seminar**

Structure of the Course

Duration: 2 hrs/ Week Credits: 2
Internal Assessment: 100 Marks

The student has to present a seminar in one of the current topics in the stream of specialization. The student will undertake a detailed study based on current published papers, journals, books on the chosen subject, present the seminar and submit seminar report.

Distribution of marks:

Seminar report : 40 marks
Presentation : 60 marks

CRE 3001 Digital Photogrammetry

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment: 40 Marks
End Semester Examination : 60 Marks

Course Objectives

- To impart knowledge in digital camera, scanners, photogrammetric Workstation and its Application with GIS and Remote Sensing.
- To familiarize the students with automatic and semi-automatic procedures in photogrammetry.
- To teach the methods of digital evaluation, its models, theories, and applications.

Learning Outcomes

- Will help the student to develop a basic understanding of the remote sensing systems used for 2D and 3D mapping
- Students will learn the basic operations in digital photogrammetry such as image orientation, image matching, and object extraction
- Students will get knowledge about the basic methods and procedures of planimetric and topographic map generation from digital stereo data

Module I

Introduction: Historical development from conventional to analytical and digital photogrammetry, Principles of analog and digital Photogrammetry. Digital cameras and scanner: Digital images and their properties, direct and indirect methods of acquisition of digital images - Digital cameras- CCD, digitizers and photogrammetric scanners; CCD camera - spectral sensitivity of CCD sensor - geometric problem of CCD image -types of CCD systems - use of CCD scanner in high resolution satellites

Module II

Digital photogrammetric procedures: Review of space resection & intersection - interior & exterior orientation - Automatic tie point generation - Automatic Block triangulation, feature collection and plotting – various formats of map data. Digital image handling: Image Generation - Data Compression - formats - Data procuring concepts - Stereo viewing - Display modes - image matching techniques - Image measurements. Modelling the geometry of imaging systems, history and evolution of 2D and 3D imaging systems, Epi-polar registration of stereo images, Orbit attitude modeling using ground control points and Rational Polynomial techniques.

Module III

Digital feature extraction and matching techniques for stereo image analysis. Use of GPS and SAR interferometry data in 3D mapping, Cartographic problems of mapping the earth with horizontal and vertical controls,Applications: DEM Generation - accuracy of DEMs, Orthorectification - contour generation - watershed delineation - satellite photogrammetry principles - stereo satellite missions - stereo image products.

References

1. Cliff Greve, Digital Photogrammetry : An addendum to the Manual of Phototgrammetry, ASPRS, 1996
2. Paul, R. Wolf, Elements of Photogrammetry, McGraw-Hill Book Co., New York, 1974.
3. Arthur H. Robinson et.al, Elements of Cartography, John Wiley & Sons, inc. 1995.
4. Quihe H. Yang, Map Projection Transformation, Taylor and Francis, London, 2000.
5. Wilfried Linder, Digital Photogrammetry: A Practical Course, Springer; 2006.
6. Ghosh, Sanjiv K., Fundamentals of Computational Photogrammetry, Concept publishing, New Delhi, 2005.
7. Zhilin Li, Qing Zhu, Chris Gold, Digital Terrain Modeling: Principles and Methodolgy, CRC; third edition, 2004.
8. John A. Richards, Xiuping Jia, Remote Sensing Digital Image Analysis: An Introduction, Springer; 4th ed. edition 2005.

Structure of the Question paper

There will be three questions from each module out of which two questions are to be answered by the students.

CRE 3002 Geoinformatics for Disaster Management

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives

- To make aware of the various principles involved and also the various mitigation to be adopted during the disasters.
- To illustrate the use of remote sensing sensors, data and geographical information system in disaster preparedness and evaluation.

Learning Outcomes

- Understand the concepts disaster management.
- Understand the application of RS, EOS, GIS, GPS tools for disaster management and mitigation.

Module I

Fundamental concepts of hazards and disasters: Characterisation and Zonation of Hazards, Hazard management cycle and information requirement for different stages, Hazard zonation principles and methods. Types of disasters and hazards: Hydrometeorological hazards: Floods, Cyclones and Coastal hazards, Drought- Geological Hazards: Landslide, Earthquake, Mining hazards (subsidence, flooding etc.), Volcanic hazards, Glacial hazards - Environmental hazards: Forest hazards (Deforestation, Degradation and Forest fire) -Land, soil degradation and desertification- Pollution (water, air and soil) - Nature of Impacts.

Module II

Utility of Remote sensing and communication systems in disaster management – use of visible, thermal and microwave remote sensing sensors for mapping and monitoring natural hazards- temporal, spatial and spectral resolution of satellite data and their role in disaster mapping and monitoring - application of EOS system for real time or near real time hazard assessment and damage assessment. Utility of GIS, GPS and Communication systems : role of GIS in mapping, modelling and simulation of hazards and preparation of Zonation maps - role of GPS in disaster related studies – role of communication technology (radio, ham radio, wireless, satellite, internet based solution etc.) for critical information dissemination- Search and rescue. Remote sensing in Hazard evaluation – Zonation – Risk assessment –Damage assessment -Warning system – Post disaster review –Case studies.

Module III

Information system management – Spatial and non-spatial data bank creation- Operational emergency management – Vulnerability analysis of infrastructure and settlements –Pre-disaster and post disaster planning for relief operations – Potential of GIS application in development planning – Disaster management plan – Case studies-Case study demonstration describing the capability & utility of EOS & GIS for disaster and hazard monitoring, assessment and mitigation. Flood mapping, Flood risk zoning, Coastal flooding assessment, Coastal erosion Assessment, drought assessment

Reference

1. Bell, F.G., Geological Hazards: Their assessment, avoidance and mitigation, E & FN SPON Routledge, London. 1999
2. David Alexander, Natural Disasters, Research Press, New Delhi, 1993
3. Nick Carter. W., Disaster Management - A Disaster Manager's Handbook. Asian Development Bank, Philippines. 1991
4. Mitigating Natural Disasters, Phenomena, Effects and options, A Manual for policy makers and planners, United Nations. New York, 1991
5. Andrew, S.,Environmental Modeling with GIS and Remote Sensing, John Willey and sons, 2002
6. Ariyabandu, M. and Sahni P. (Eds), Disaster Risk Reduction in South Asia, Prentice-Hall (India), 2003.
7. Bossler, J.D., Manual of Geospatial Science and Technology, Taylor and Francis, London, 2001
8. Matthews, J.A., Natural hazards and Environmental Change, Bill McGuire, Ian Mason, 2002

Structure of the Question paper

There will be three questions from each module out of which two questions are to be answered by the students.

CRE 3003 Advanced Techniques in Image Processing

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment: 40 Marks
End Semester Examination : 60 Marks

Course Objectives

- To provide a seminal view on recent advances in techniques for image processing
- To familiarize the techniques that help to deal with the high dimensional nature of the data, and also to integrate the spatial and spectral information

Learning Outcomes

- Students will be familiar with the new trends in algorithm design such as the joint use of spatial and spectral information
- Will help the students to deal with the increasing sophistication in the rapidly maturing field digital image processing

Module I

Advanced Classifiers: Introduction to fuzzy theory and fuzzy classification Methods - Artificial neural networks and classification Methods-Classification accuracy assessment, Error matrix and fuzzy error matrix

Module II

Spatial Transformation Techniques Texture analysis – first order, second order texture parameters. Morphological methods for satellite image analysis. Digital image segmentation concepts - Edge and region segmentation of satellite images. Wavelet transform and its application in RS image analysis

Module III

Hyperspectral remote sensing data acquisition systems, Imaging Spectroscopy. Hyperspectral Image Analysis: Calibration and normalization of hyperspectral images, feature and intensity based geometric and image to image registration, methods and models for atmospheric correction. Hyperspectral image compression - Feature selection and feature extraction techniques - Discriminant analysis, Independent component analysis

References

1. Mather P.M., Computer Processing of Remotely Sensed Images, Wiley, 2004
2. Brandt Tso and P.M. Mather, Classification Methods for Remotely Sensed Data, Taylor and Francis, 2001
3. Kenneth R. Castleman, Digital Image Processing, Prentice-Hall, 1997
4. Manual Of Remote Sensing, American Society Of Photogrammetry And Remote Sensing, 1999
5. Artificial Neural Networks: A Comprehensive Foundation, Longman, 2nd Edition, 1999

6. Cheng, Chein I., Hyperspectral Imaging: Techniques for Spectral Detection and Classification, Kluwer Acedmic., 2003
7. Varshney, P.K. and Arora, Manoj K., Advanced Image Processing Techniques for Hyperspectral Remote Sensing Data, Springer-Verlag., 2004

Structure of the Question paper

There will be three questions from each module out of which two questions are to be answered by the students.

CRE 3004 Digital Terrain Modelling

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment: 40 Marks
End Semester Examination : 60 Marks

Course Objective

- Expose the students with digital terrain modelling
- To provide exposure to the generation of TIN
- To introduce visualization and applications of DTM.

Learning outcome

- Ability to select suitable source of data for DTM
- Ability to do proper interpolation to create surface
- Ability to interpret DTM and apply to various applications

Module I

Introduction: representation of digital terrain surfaces,, DEM, digital terrain modelling. Terrain descriptors and sampling strategies: Qualitative and numeric terrain descriptors, terrain roughness vector-slope, relief and wavelength, sampling strategy for data acquisition, attributes of sampled data. Data acquisition: data sources of DTM, Radargrammetry, SAR interferrometry, Airbourne laser scanning, cartographic digitization. Digital terrain surface modelling: surface modelling approaches- point based, triangle based, grid based, hybrid, Continuity of DTM surfaces, Triangular Network formation for surface modelling, Grid network formation for surface modelling

Module II

Generation of Triangular Irregular Networks: Delaunay triangulation- vector based static, vector based dynamic, constrained, Triangulation from contour data, triangulation from Voronoi diagrams. Interpolation techniques for terrain surface modelling: linear interpolation, bilinear interpolation, bicubic spline interpolation, least square fitting of local surface, point based moving averaging. Quality control in terrain data acquisition: sources and types of errors, filtering of random errors, detection of errors- gross errors based on slope information, isolated gross errors in irregularly distributed data, cluster of gross errors, gross errors based on topologic relations of contour.

Module III

Contouring from digital terrain models: vector and raster based contouring from grid DTM and Triangular DTM. Visualization of digital terrain models: variables for visualisation, 2D and 3D visualisation, texture mapping, animation techniques. Interpretation of digital terrain models: Terrain parameters-geometric, morphological, hydrological, visibility. Applications of digital terrain models: Runoff calculations, Mining, water and soil conservation

References

1. Li, Z., Zhu, Q., and Gold, C., Digital Terrain Modelling Principles and Methodology, CRC Press, 2005
2. Robert J. Peckham, R. J. & Gyozo Jordan, Digital Terrain Modelling, Development and Applications in a Policy Support Environment, Springer, 2007
3. Naser El-Sheimy, Caterina Valeo, Digital Terrain Modeling: Acquisition, Manipulation And Applications, 2005.

4. John P. Wilson & John C. Gallant, Terrain Analysis : Principles and Applications . Wiley, New York, 2000.

Structure of the Question paper

There will be three questions from each module out of which two questions are to be answered by the students.

CRE 3005 Remote sensing and GIS Applications in Water Resources Engineering

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment: 40 Marks
End Semester Examination : 60 Marks

Course Objectives

- Expose the students with the applications of RS and GIS in water resources Engineering

Learning outcomes

- The ability to understand various data required for water resources projects
- The ability to apply the various remote sensing products in water resources related activities

Module I

Principle of remote sensing in water resources assessment, spectral characteristics of water/snow and surface water inventory, hydrologic elements and classification

Module II

Creation and design of spatial and non spatial data in water resources, DEM applications in water resources, basic concepts of hydrologic modelling, watershed hydrology and physical processes in watershed, Erosion and sediment yield modelling, watershed prioritization, watershed conservation planning

Module III

Geo-engineering consideration for investigation of hydel sources, river valley project planning, Environmental impact assessment of water resources project

Drought monitoring, water balance studies, flood mapping and risk zoning, reservoir sedimentation, watershed modelling, soil moisture studies, ground water modelling , water quality using multi spectral and hyper spectral remote sensing data Infiltration, runoff estimation- SCS-CN, Evapotranspiration, soil moisture, soil properties

References

1. Ven Te Chow, Hand book of Applied Hydrology, Mc-Graw Hill, New York, 1964
2. Keith P. B., Thompson et al.(Ed.), Remote sensing and water resources management, American water rsources association, Urbana Illinois, 1973
3. Colwel R. N. (Ed.), Manual of remote sensing, vol. I and II, American society of photogrammetry and Remote sensing, Falls Church, Va., 1983

Structure of the Question paper

There will be three questions from each module out of which two questions are to be answered by the students.

CRE 3006 Applications of Geoinformatics in Coastal Engineering

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment: 40 Marks
End Semester Examination : 60 Marks

Course Objectives

- To understand the different coastal processes and coastal protection measures.
- To illustrate the application of RS data and GIS for coastal zone management.

Learning outcomes

- Understand the coastal processes and coastal mitigation measures adopted.
- Capability to use remotely sensed data products for the coastal engineering studies.
- Understand the usage of GIS in Coastal Zone management studies.

Module I

Coastal and littoral zones – definitions and scope of study-Shore zone processes –Coastal landforms, Coastal classification. Coastal wetlands – Mangrove swamps, marshes, lagoons, tidal channels/creeks and their significance in coastal stability.Sea level changes – factors involved, effects of sea level oscillations on coastal zones.Global warming and Sea level rise - impact on coastal zones; coastal vulnerability assessment.Coastal processes – waves, tides and currents - Waves – surface waves - Water motion in waves – reflection, diffraction and refraction – wave generated currents – catastrophic waves current Measurement-Tides – Tidal forces – littoral drift.Physical oceanographic parameter estimation – sea surface temperature – significant wave height – wind speed and direction – coastal bathymetry.

Module II

Coastal Engineering : Coastal Hydrodynamics – Coastal erosion and protection – different Coastal protection works – design of Breakwaters – Estuaries and their impact on coastal processes-Hydrodynamics of pollution dispersion.Coastal vegetation; shelter belts; coastal aquifers; freshwater-seawater interface.Coastal Hazards : Storm surges and Tsunamis : Origin, propagation and run-up of tsunamis; Tsunami impact – role of coastal topography and vegetation. Coastal hazard preparedness – coastal protection, education and awareness of coastal communities

Module III

Coastal zone management – concepts, models and information systems - creation of CZIS – Coastal Regulation zone – Integrated coastal Management using GIS.Human activity and coastal environment – deforestation, agriculture/aquaculture, pollution and coastal structures, and their effect on coastal zones -Remote Sensing applications: Use of Microwave data – CZCS studies – various sensors used for coastal application ,application of remote sensing in coastal zone studies. Role of Geographic Information Systems in coastal zone studies

References

1. Johnb.Herbich, Handbook of Costal Engineering, McGraw-Hill Professional; 1st ed., 2000.
2. Robert G. Dean, Robert A. Dalrymple , Water Wave Mechanics for Engineers and Scientists, World Scientific Publishing Company, 1990.
3. William Kamphuis J, Introduction To Coastal Engineering And Management, World Scientific Publishing Company, 2000.
4. Biliana Cicin-Sain Gunnar Kullenberg, Integrated Coastal and Ocean Management: Concepts and Practices, Island Press, 1st ed. 1998
5. Sain, B.C., and Knecht, R.W, Integrated Ocean and Coastal Management, UNESCO Publication, 1998
6. Satake, K. (ed),Tsunamis – case studies and recent developments, Springer, 2005

Structure of the Question paper

There will be three questions from each module out of which two questions are to be answered by the students.

CRC 3101 Thesis Preliminary (Part II)

Structure of the Course

Duration: 15 hrs/ Week Credits: 5

Continuous Internal Assessment: 200 Marks

Thesis Preliminary part II comprises of a preliminary thesis work, two seminars and submission of thesis preliminary report. The first seminar would highlight the topic, objectives, and methodology and the second seminar is on the presentation of the work completed till the third semester and the scope of the work which is to be accomplished in the fourth semester, mentioning the expected results.

CRC 4101 **Thesis**

Structure of the Course

Lecture: 21hrs/week Credits : 12

The fourth semester is entirely devoted for the thesis work. There would be an interim presentation at the first half of the semester to evaluate the progress of the work and at the end of the semester there would be a Pre-Submission seminar before the Evaluation Committee for assessing the quality and quantum of the work. This would be the qualifying exercise for the students for getting approval from the Department Committee for the submission of Thesis. At least one technical paper is to be prepared for possible publication in Journals/ Conferences. The final evaluation of the Thesis would be conducted by the board of examiners constituted by the University including the Guide and an external examiner.

Distribution of marks

Internal evaluation of the Thesis work by the guide: 150 marks
Internal evaluation of the Thesis by the Evaluation Committee: 150 marks
Final evaluation of the Thesis Work by the Internal and External Examiners:
[Evaluation of Thesis: 200 marks *+ Viva Voce: 100 marks *(*5% of the marks is ear marked for publication in Journal/Conference)*] TOTAL – 300 marks