

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CE-241** Course Title: **Fluid Mechanics**

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

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

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

5. Credits: 4

6. Semester: **Autumn**

7. Subject Area: **DCC**

8. Pre-requisite: **Nil**

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

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Fluid properties, types of fluids, continuum principle	3
2.	Principles of Fluid Statics: Basic equations, manometers, hydrostatic forces on submerged surfaces, buoyancy.	7
3.	Kinematics of Flow: Visualisation of flow, types of flow, streamline, pathline, streakline, conservation of mass, velocity field, acceleration, vortex flow, velocity potential and stream function.	4
4.	Fluid Dynamics: System and control volume approaches, Euler's equation, Bernoulli's equation and its applications, Reynolds transport equation, momentum and angular momentum equations and their applications.	7
5.	Dimensional Analysis and Similitude: Dimensional homogeneity, Buckingham's π method, dimensionless number, similitude.	3
6.	Boundary Layer Theory: Concept of boundary layer, laminar and turbulent boundary layer, boundary layer thickness, von Karman integral equation, laminar sublayer, hydrodynamically smooth and rough boundaries, separation of flow and its control, cativation.	6
7.	Laminar and Turbulent Flow through Pipes: Laminar flow through pipes, turbulent flow, Reynolds equations, Prandtl's mixing length theory, velocity distribution over a plate and through pipe,	9

	Darcy-Weisbach equation, friction factor, moody diagram, minor losses, pipe network, venturimeter, orifice meter, water hammer, surge tanks	
8.	Drag and Lift: Skin-friction and form drag, drag on sphere, cylinder and flat plate, Karman vortex shedding, generation of lift around a cylinder, lifting vanes.	3
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication
1.	Fox, R.W. and McDonald, A.T., "Introduction to Fluid Mechanics", John Wiley & Sons.	2004
2.	Garde, R.J. and Mirajgaoker, A.G., "Engineering Fluid Mechanics", Nem Chand & Bros.	1988
3.	Kumar, K.L., "Engineering Fluid Mechanics", Eurasia Publishing House.	2000
4.	Schlichting, H. and Gersten, K., "Boundary Layer Theory", Springer.	2004
5.	Streeter, V.L. and Benjamin, W.E., "Fluid Mechanics", McGraw-Hill.	1983
6.	Som, S.K. and Biswas, G., "Fluid Mechanics and Fluid Mechanics", Tata McGraw Hill.	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CE-251** Course Title: **Building Materials, Construction & Estimation**

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

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

4. Relative Weightage: **CWS** **PRS** **MTE** **ETE** **PRE**

5. Credits:

6. Semester: **Autumn**

7. Subject Area: **DCC**

8. Pre-requisite: **Nil**

9. Objective: To introduce the fundamentals of building materials, construction, drawings and estimation of construction cost.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Brick masonry; bonds, stone masonry; types of walls, plastering and pointing.	7
2.	Types of roofs, floors and foundations, damp proofing.	3
3.	Doors and windows, stairs, staircases, lifts and escalators.	5
4.	White washing, colour washing, painting, and distempering, Shuttering, scaffolding and centering.	6
5.	Expansion and construction joints, sound and fire proof construction, principles of building drawing; preparation of working drawings.	6
6.	Common building materials, brick masonry, cement, concrete, steel/timber, wood products and wood substitutes.	3
7.	Introduction to glass, plastics with/without reinforcement, aluminium alloys, fibre reinforced concrete and ferrocement, energy efficient materials for green buildings.	6
8.	Quantity Estimation: Methods of estimation, analysis of rates, schedule of rates, estimation of materials, labour and cost.	6
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication
1.	Kumar, S., “Building Construction”, Standard Publishers.	2005
2.	Dayaratnam, P., “Brick and Reinforced Brick Structures”, Oxford and IBH.	1987
3.	Arya, A.S., “Masonry and Timber Structures including Earthquake Resistant Design”, Nem Chand & Bros.	1992
4.	Goyal, M.M., “Handbook of Building Construction”, Amrindia Consultancy.	2004
5.	Dutta, B.N., “Estimation and Costing”, S. Dutta & Co.	2000
6.	Khanna, P.N., “Indian Practical Civil Engineering Handbook”, Engineers Publishers.	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CE-212** Course Title: **Water Supply Engineering**

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

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

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

5. Credits:

4

6. Semester: **Spring**

7. Subject Area: **DCC**

8. Pre-requisite: **Nil**

9. Objective: To impart understanding of various aspects related to supply of pure and safe drinking water to communities and the conservation of water.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction and scope, source of water supply, water quality : physical, chemical and biological characteristics, water demand.	7
2.	Water collection and treatment, conventional treatment; settling, coagulation-flocculation, filtration and disinfection, advanced treatment; activated carbon adsorption and ozonation, design of facilities.	9
3.	Water distribution, storage reservoirs, distribution networks.	3
4.	Water transportation, water pipes, water leakage.	3
5.	Water supply in building, plumbing and fixtures.	3
6.	Water conservations, rainwater harvesting, small water supply systems.	3
	Total	28

List of Experiments :

1. Characterization of water & wastewater quality
2. Air sampling and analysis
3. Measurement of noise
4. Coagulation flocculation
5. Disinfection

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication
1.	Hammer, M.J. and Hammer, M.J., “Water and Wastewater Technology”, 4 th Ed., Prentice Hall of India.	2000
2.	Davis, M.L. and Cornwell, D.A., “Introduction to Environmental Engineering”, McGraw Hill.	1998
3.	McGhee, T.J., “Water Supply and Sewerage”, McGraw Hill.	1991
4.	Peavy, H.S., Rowe, D.R. and Tehobanoglous, G., “Environmental Engineering”, McGraw Hill.	1986

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CE-222** Course Title: **Principles of Surveying**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge about basic principles of field surveying procedures and practices for civil engineering applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Importance of surveying to engineering projects, basic principles.	2
2.	Type of maps, scales and uses, plotting accuracy, map sheet numbering, coordinate and map projection.	4
3.	Surveying equipment, levels, compass, theodolites, tachometer, EDM, total Stations and other instruments.	5
4.	Measurement of angles, directions and distance.	5
5.	Determination of elevation, spirit leveling, trigonometrical leveling, and tachometric surveying, contouring.	8
6.	Methods of control establishment, traversing, triangulation, trilateration, adjustment of survey measurements, computation of coordinates.	6
7.	Plane table surveys and mapping, curve layout, horizontal, transition and vertical curves.	8
8.	Astronomical terms, determination of azimuth.	4
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication
1.	Anderson, J.M. and Mikhail, E.M., “Surveying: Theory and Practice”, McGraw Hill.	1998
2.	Arora, K.R., “Surveying”, Vol. I, II and III, Standard Book House.	1995
3.	Chandra, A.M., “Surveying”, New Age Publishers.	2002
4.	Schofield, W. and Breach M., “Engineering Surveying”, 6 th Ed., Butterworth-Heineman.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CE-242** Course Title: **Channel Hydraulics**

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

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

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

5. Credits: **4**

6. Semester: **Spring**

7. Subject Area: **DCC**

8. Pre-requisite: **CE-241**

9. Objective: To introduce the concepts of channel hydraulics, used in design of inland waterways for irrigation and navigation.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to Free Surface Flows : Comparison between pipe and channel flows, basic equations governing channel flows.	3
2.	Uniform Flow : Flow resistance in channel flows, resistance relationships, normal depth, section factor for uniform flow computation, design of channels, most efficient cross-section in rigid boundary channels.	7
3.	Fluvial Hydraulics : Incipient motion condition, regimes of flow and resistance to flow in mobile bed channels, non-scouring erodible boundary channel design, alluvial channel design, uniform flow in mobile bed channels.	6
4.	Concepts of Specific Energy and Specific Force : Section factor for critical flow computation, critical depth computations, control sections, applications of specific energy and critical depth.	6
5.	Gradually Varied Flow : Governing equations, characteristics and classification of water surface profiles, computations of GVF profiles in prismatic and non-prismatic channels.	5
6.	Hydraulic Jump : Types of jump, hydraulic jump in horizontal rectangular channels, forced jump, hydraulic Jump in non-rectangular and sloping channels, stilling basins.	5

7.	Flow Measurement in Open Channels : Broad and sharp-crested weirs, free overall, flow over spillways, side weirs, sluice gates.	5
8.	Unsteady Flow : Wave celerity, surges, governing equations, method of characteristics, flood routing in channels, dam break analysis.	5
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication
1.	Ranga Raju, K.G., “Flow through Open Channels”, Tata McGraw-Hill.	2003
2.	Chow, V.T., “Open Channel Hydraulics”, McGraw Hill.	1959
3.	Chanson, H., “The Hydraulics of Open Channel Flow: An Introduction”, Elsevier Scientific.	2004
4.	Asawa, G.L., “Fluid Flow in Pipes and Channels”, CBS Publishers.	2008
5.	Subramanya, K., “Flow in Open Channels”, Tata McGraw-Hill.	1997

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CE-252** Course Title: **Structural Analysis-I**

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

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

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

5. Credits: **4**

6. Semester: **Spring**

7. Subject Area: **DCC**

8. Pre-requisite: **Nil**

9. Objective: To introduce the fundamentals of the analysis of statically determinate and indeterminate structures

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Analysis of statically determinate beams, frames and trusses.	4
2.	Deflection of frames and trusses, conjugate beam and area moment theorems; unit load method.	8
3.	Strain energy method for slopes and deflections.	4
4.	Statically indeterminate structures, static and kinematic indeterminacies.	2
5.	Castigliano's theorems, theory of least work.	2
6.	Use of symmetry and antisymmetry, approximate methods for the analysis of building frames.	2
7.	Analysis of indeterminate structures by flexibility method, consistent deformation method, strain energy method, influence coefficient method, Column analogy method.	10
8.	Analysis of three hinged, two hinged and fixed arches, analysis of cables and two hinged suspension bridges, unsymmetrical bending and shear centre.	10
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication
1.	William F. Riley et al., “Mechanics of Materials”, John Wiley & Sons.	2004
2.	Norris, C.H. et.al., “Elementary Structural Analysis”, Tata McGraw Hill.	2003
3.	Hibbeler, R.C., “Structural Analysis”, Pearson Press.	2007
4.	Wang, C.K., “Intermediate Structural Analysis”, McGraw Hill.	1987
5.	Reddy, C.S., “Basic Structural Analysis”, Tata McGraw Hill.	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CE-311** Course Title: **Waste Management**

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

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

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

5. Credits: 4

6. Semester: **Autumn**

7. Subject Area: **DCC**

8. Pre-requisite: **Nil**

9. Objective: To impart basics of waste collection, its characterization, treatment and safe disposal practices.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Wastewater Collection: Plumbing, types of sewers, design considerations, construction & maintenance, stormwater sewers.	6
2.	Wastewater Characterization: Constituents.	2
3.	Wastewater Treatment: On site and centralized treatment systems.	2
4.	Pre-and Primary Treatment : Screen, grit removal, oil and grease removal.	3
5.	Secondary Treatment : Activated sludge process, conventional and extended aeration, waste stabilization ponds, UASB process, UASB post treatment.	9
6.	Advanced Wastewater Treatment.	2
7.	Wastewater and Sludge Disposal: Reuse systems, wastewater disposal on land and water bodies, disposal of sludge.	4
8.	Municipal Solid Waste: Collection, characterization, transport, treatment & disposal,	6
9.	Types of Industrial Waste: Liquid, solid, atmospheric and hazardous, Hazardous wastes : Characterization and treatment.	8
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication
1.	Davis, M.L. and Cornwell, D.A., “Introduction to Environmental Engineering”, McGraw Hill.	1998
2.	Masters, G.M., “Introduction to Environmental Engineering and Science”, Prentice Hall of India.	1998
3.	Peavy, H.S., Rowe, D.R. and Tchobanoglous, G., “Environmental Engineering”, McGraw Hill.	1986
4.	Arcievala, S.J., “Wastewater Treatment for Pollution Control”, Tata McGraw Hill.	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CE-321** Course Title: **Geomatics Engineering**

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

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

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

5. Credits: **4**

6. Semester: **Autumn**

7. Subject Area: **DCC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of concepts advanced surveying, photogrammetry, remote sensing, Geographic Information Systems (GIS) and Global Positioning Systems (GPS).

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction of Geomatics Engineering.	1
2.	Photogrammetry, aerial and terrestrial, applications of photogrammetry, types and geometry of aerial photograph, flying height and scale, relief (elevation) displacement.	6
3.	Stereoscopy, measurement and parallax and height determination, photogrammetric mapping.	6
4.	Basic remote sensing, interaction mechanism with atmospheric and earth surface, platforms and sensors, remote sensing data products, visual data interpretation for information extraction.	7
5.	Digital data bank, digital image, introduction to digital image processing, preprocessing, enhancement, classification.	8
6.	Introduction of geographic information system (GIS), digital elevation model (DEM).	7
7.	Introduction to GPS surveys.	4
8.	Applications to various projects.	3
	Total	42

Note: Includes field survey camp for 10 days.

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication
1.	Agarwal, C.S. and Garg, P.K., “Remote Sensing in Natural Resources Monitoring and Management”, Wheeler Publishing House.	2000
2.	Bossler, J.D., “Manual of Geospatial Science and Technology”, Taylor and Francis.	2002
3.	Burrough, P.A. and McDonnell, R.A., “Principles of Geographic Information System”, Oxford University Press.	2000
4.	Chandra, A.M. and Ghosh, S.K., “Remote Sensing and Geographical Information Systems”, Alpha Science.	2005
5.	Gopi, S., “Global Positioning System: Principles and Applications”, Tata McGraw Hill.	2005
6.	Lillesand, T.L., and Kiefer, R.W., “Remote Sensing and Image Interpretation”, 4 th Ed., John Wiley and Sons.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CE-331** Course Title: **Soil Mechanics and Engineering Geology**

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

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

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

5. Credits: 5

6. Semester: **Autumn**

7. Subject Area: **DCC**

8. Pre-requisite: **Nil**

9. Objective: To provide basic concepts of soil mechanics and engineering geology.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Soil Formation : Soil types, composition, three phase relations.	2
2.	Physical Properties : Specific gravity, water content, shape and size, grain size distribution curves, relative density, consistency of soils, Unified soil classification system, IS soil classification system, field identification tests.	5
3.	Compaction : General principles, tests, factors affecting compaction, field compaction, compaction techniques.	2
4.	Capillarity, Permeability : Darcy's law, determination of permeability, equivalent permeability in stratified soils, insitu permeability test, 1-D flow, Laplace's equation, flow nets, seepage, uplift pressure, confined and unconfined flows, piping, filter criteria.	10
5.	Compressibility and Consolidation : Fundamentals, 1-D consolidation, normally and over-consolidated clays, void ratio – pressure relationships, compressibility characteristics, time rate of consolidation, coefficient of consolidation, curve fitting techniques, settlement, secondary consolidation, 3-D consolidation, vertical sand drains.	7
6.	Shear Strength of Soil : Principle of effective stress, Mohr-Coulomb failure criterion, direct shear test, unconfined compression test, Triaxial shear test : consolidated drained, consolidated undrained, unconsolidated undrained, vane shear test, shear strength of clays and sands, critical void ratio, stress path, pore-pressure coefficient.	10

7.	Geological Processes : Rock forming minerals, rock types and their engineering properties.	2
8.	Structural Geology : Dip, strike, faults, folds, joints, their formation and importance in respect of civil engineering structures, rock mass movements, causes of landslides.	4
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication
1.	Holtz, R.D. and Kovacs, W.D., “An Introduction to Geotechnical Engineering”, Prentice Hall.	1981
2.	Couduto, D.P., “Geotechnical Engineering – Principles and Practices”, Prentice Hall of India.	2002
3.	Ranjan, G. and Rao, A.S.R., “Basic and Applied Soil Mechanics”, New Age International Publishers.	2007
4.	Murthy, V.N.S., “Text Book of Soil Mechanics and Foundation Engineering”, CBS Publishers.	2007
5.	Lambe, T.W. and Whitman, R.V., “Soil Mechanics”, John Wiley and Sons.	2000
6.	Das, B.M., “Principles of Geotechnical Engineering”, Thomson Asia.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CE-341** Course Title: **Hydrology**

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

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

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

5. Credits: **2**

6. Semester: **Autumn**

7. Subject Area: **DCC**

8. Pre-requisite: **Nil**

9. Objective : To familiarize the students with the concepts of hydrological process, climate change and rain harvesting.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Hydrological Cycle and Budget : Definitions, space – time scales in hydrology, hydrologic cycle and budget.	2
2.	Precipitation Measurement and Analysis : Precipitation variability, rainfall and snow measurement techniques, design of precipitation gauging network, consistency of rain record, filling up of missing record, estimation of mean areal rainfall, IDF and DAD analysis, Snow measurement and determination of snow melt.	5
3.	Hydrologic Abstractions : Infiltration, factors affecting infiltration, measurement of infiltration, empirical and analytical models of infiltration, evaporation: its measurement and estimation, evapo-transpiration: its measurement and estimation, interception and depression storage; rain harvesting: procedure and its design.	5
4.	Stream Flow : Measurement of stream flow; factors affecting stream flow; hydrograph analysis, base flow separation, unit hydrograph and curve number methods of stream flow determination, synthetic unit hydrograph, hydrological modeling for stream flow estimation, methods for peak discharge estimation.	5
5.	Frequency Analysis : Return period, random variable, checks for persistency, frequency distributions, frequency analysis of	4

	hydrological data.	
6.	Regression and Correlation Analysis: Dependent and independent variables, simple correlation coefficient, method of least squares, variance analysis, partial correlation coefficient, simple and multiple regression analysis.	3
7.	Ground Water: Aquifers, hydraulic conductivity, transmissivity, well hydraulics.	2
8.	Flood Routing: Governing equations, reservoir flood routing, hydrologic routing: Muskingum method.	2
	Total	28

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication
1.	Singh, V.P., “Elementary Hydrology”, Prentice Hall.	1992
2.	Chow, V.T., Maidment, D.R. and Mays, W.L., “Applied Hydrology”, McGraw Hill.	1988
3.	Wanielista, M., Kersten, R. and Eaglin, R., “Hydrology”, John Wiley.	1997
4.	Ojha, C.S.P., Berndtsson, R. and Bhunya, P., “Engineering Hydrology”, Oxford University Press.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CE-351** Course Title: **Structural Analysis-II**

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

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

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

5. Credits:

4

6. Semester: **Autumn**

7. Subject Area: **DCC**

8. Pre-requisite: **CE-252**

9. Objective: To introduce the stiffness approach for analysis of statically indeterminate structures.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Influence Lines : Analysis for different types of moving loads, use of influence line diagrams, application to determinate structures.	7
2.	Muller-Breslau principle with application to determinate and redundant structures. Qualitative ILD for continuous beams, frames and arches.	6
3.	Displacement approach; basic principles.	3
4.	Slope deflection method.	4
5.	Moment distribution method, frame with/without sway, use of symmetry and anti-symmetry	5
6.	Matrix displacement method, basic principles, application to planar structures-trusses, beams and frames. Introduction to computer program and applications to 2D building frames.	13
7.	Plastic analysis of beams and frames.	4
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication
1.	Wang, C.K., “Intermediate Structural Analysis”, McGraw Hill.	1987
2.	Norris, C.H. et.al., “Elementary Structural Analysis”, Tata McGraw Hill.	2003
3.	James, M. Gere, “Mechanics of Materials”, 5 th Ed., Nelson Thornes.	2002
4.	Reddy, C.S., “Basic Structural Analysis”, Tata McGraw Hill.	2000
5.	Weaver, W. Jr. and Gere, J.M., “Matrix Analysis of Framed Structures”, CBS Publishers.	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CE-332** Course Title: **Foundation Engineering**

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

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

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

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

8. Pre-requisite: **CE-331**

9. Objective: To provide knowledge base on the current practices in foundation engineering to carry out the job of selection, design and construction of foundations.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Role of civil engineer in the selection, design and construction of foundation of civil engineering structures, brief review of soil mechanics principles used in foundation engineering.	3
2.	Soil Exploration: Methods of soil exploration; boring, sampling, penetration tests, correlations between penetration resistance and soil design parameters.	4
3.	Earth Pressure and Retaining Walls: Earth pressure at rest, active and passive earth pressure, Rankine and Coulomb's earth pressure theories, earth pressure due to surcharge, retaining walls, stability analysis of retaining walls, proportioning and design of retaining walls.	6
4.	Foundations: Types of foundations, mechanism of load transfer in shallow and deep foundations, shallow foundations, Terzaghi's bearing capacity theory, computation of bearing capacity in soils, effect of various factors, use of field test data in design of shallow foundations, stresses below the foundations, settlement of footings and rafts, proportioning of footings and rafts, sheeting and bracing of foundation excavation.	11
5.	Pile Foundation: Types and methods of construction, estimation of pile capacity, capacity and settlement of group of piles, proportioning of piles.	5

6.	Well foundations: Methods of construction, tilt and shift, remedial measures, bearing capacity, settlement and lateral stability of well foundation.	4
7.	Slopes: Mode of failure – mechanism, stability analysis of infinite slopes, methods of slices, Bishop’s simplified method.	5
8.	Machine Foundations: Types of machine foundations, mathematical models, response of foundation – soil system to machine excitation, cyclic plate load test, block resonance test, criteria for design.	4
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication
1.	Ranjan, G. and Rao, A.S.R., “Basic and Applied Soil Mechanics”, New Age.	2000
2.	Das, B.M., “Principles of Foundation Engineering”, PWS.	2004
3.	Som, N.N. and Das, S.C., “Theory and Practice of Foundation Design”, Prentice-Hall.	2003
4.	Couduto, Donald P., “Geotechnical Engineering – Principles and Practices”, Prentice-Hall.	1999
5.	Peck, R.B., Hanson, W.E. and Thornburn, T.H., “Foundation Engineering”, John Wiley.	1974

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CE-352** Course Title: **Design of Reinforced Concrete Elements**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To introduce the fundamentals of reinforced concrete design

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Properties of Concrete : Compressive strength, tensile strength, stress-strain behavior, modulus of elasticity, shrinkage, creep, characteristic strength, grades of concrete, design stress-strain curve of concrete, reinforcing steel, types and grades, stress-strain behavior, design stress-strain curve.	5
2.	Basic Concepts of Reinforced Concrete Design : Working stress and limit state design methods.	3
3.	Design of R.C. Beams in Flexure : Singly and doubly reinforced rectangular/flanged sections, design for shear, bond and anchorage of reinforcement, limit states of deflection and cracking.	8
4.	Design for Torsion : Design of RC beams subjected to torsion.	5
5.	One-way and two-way slabs, design of staircases.	5
6.	Design of compression members for axial loads and axial load plus uniaxial moment.	6
7.	Foundation types, design of isolated footings, introduction to combined footings.	4
8.	Stability analysis of retaining walls, design of gravity, cantilever type retaining walls.	6
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication
1.	Shah, V.L. et.al., “Limit State Theory and Design of Reinforced Concrete”, Structures Publications.	2007
2.	Pillai, S.U. and Menon, D., “Reinforced Concrete Design”, Tata McGraw- Hill.	2003
3.	Varghese, P.C., “Limit State Design of Reinforced Concrete”, Prentice-Hall.	2002
4.	Park, R. and Pauley, T., “Reinforced Concrete Structures”, John Wiley.	1976
5.	Gambhir, M.L., “Fundamentals of Reinforced Concrete Design”, Prentice-Hall of India.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CE-354** Course Title: **Design of Steel Elements**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of design of basic structural steel elements as per relevant codal practices.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction, properties of structural steel, I.S. rolled sections, I.S. specifications.	2
2.	Design approach, elastic method, limit state design.	2
3.	Connections, simple and moment resistant riveted, bolted and welded connections.	3
4.	Tension members, steel members subject to axial tension.	2
5.	Compression members, struts and columns.	3
6.	Roof trusses, roof & side coverings, design loads, purlins, members, end bearings.	2
7.	Built-up columns, beams, stability of flange and web, built-up sections.	5
8.	Plate-girders including stiffeners, splices and curtailment of flange plates.	4
9.	Beam column, stability consideration, interaction formulae, column bases, slab base, gusseted base and grillage footings.	5
	Total	28

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication
1.	Arya, A.S. and Ajmani, J.L., “Design of Steel Structures”, Nem Chand & Bros.	2000
2.	Duggal, S.K., “Design of Steel Structures”, Tata McGraw-Hill.	2006
4.	Negi, L.S., “Design of Steel Structures”, Tata McGraw-Hill.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CE-362** Course Title: **Transportation Engineering-I**

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

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

4. Relative Weightage: **CWS** 15 **PRS** 15 **MTE** 20 **ETE** 40 **PRE** 10

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

8. Pre-requisite: **Nil**

9. Objective: To introduce the fundamentals and present practices of pavement engineering, highway construction, traffic engineering and geometric design.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Highway Development and Planning: Historical Development, road patterns, master plans, road development plans, PMGSY, engineering surveys, highway projects.	6
2.	Highway Materials and Testing: Subgrade soil, sub base and base course materials, bituminous materials, testing of soil, stone aggregates and bitumen.	6
3.	Highway Geometric Design: Cross section elements, sight distances, horizontal and vertical alignment.	6
4.	Traffic Engineering: Traffic characteristics, road user & vehicular characteristics, traffic studies, accident studies, traffic operations, traffic control devices, intelligent transport systems, pollution due to traffic.	8
5.	Design of Highway Pavements: Flexible pavements and their design, review of old methods, CBR method, IRC:37-2001, equivalent single wheel load factor, rigid pavements, stress in rigid pavement, IRC design method (IRC:58-2002).	6
6.	Highway Construction: Construction of various layers, earthwork, WBM, GSB, WMM, various types of bituminous layers, joints in rigid pavements	6
7.	Highway Maintenance: Various type of failures, evaluation and remedial measures.	4
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication
1.	Khanna, S.K. and Justo, C.E.G., “Highway Engineering”, Nem Chand & Bros.	2004
2.	Khanna, S.K. and Justo, C.E.G., “Highway Material Testing Manual”, Nem Chand & Bros.	2004
3.	Kadiyali, L.R., “Traffic Engineering and Transportation Planning”, Khanna Publishers.	2002
4.	Sharma, S.K., “Principles and Design of Highway Engineering”, S. Chand & Co.	1995
5.	Papacostas, C.S. and Prevedouros, P.D., “Transportation Engineering and Planning”, Prentice Hall.	2002
6.	Jotin Khisty, C. and Kent Lall, B., “Transportation Engineering – An Introduction”, Prentice Hall.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CE-451** Course Title: **Design of Reinforced Concrete Structures**

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

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

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

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

8. Pre-requisite: **CE-352**

9. Objective: To introduce the concepts of the analysis and design of concrete buildings, pre-stressed concrete structures and water tanks.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Design of continuous R.C. beams, moment redistribution.	3
2.	Design loads on buildings, wind and earthquake loads.	3
3.	Analysis and design of RC framed buildings; Framing systems, member proportioning, loadings, static and dynamic analysis and component design, provisions of ductile detailing.	5
4.	Design of T-beams bridge, standard specifications and general design considerations.	5
5.	Design of overhead water tanks, general design consideration for circular & Intze tanks.	6
6.	Pre-stressed concrete; Materials, prestressing systems, stress analysis & losses of prestress, design of simple beams.	6
	Total	28

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication
1.	Jain, A.K., "Reinforced Concrete", Limit State Design, 5 th Ed., Nem Chand & Bros.	2006
2.	Krishna, J. and Jain O.P., "Plain and Reinforced Concrete", Vol. 2, Nem Chand and Bros.	1983
3.	Pillai, S.U. and Menon, D., "Reinforced Concrete Design", Tata McGraw-Hill.	2003

4.	Sinha, S.N., “Reinforced Concrete Design”, Tata McGraw-Hill.	2005
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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CE-461** Course Title: **Transportation Engineering-II**

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

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

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

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

8. Pre-requisite: **CE-362**

9. Objective of Course: To introduce the fundamentals of railway engineering, geometric design of railway tracks and runways.

10. Details of the Course.

S. No.	Contents	Contact hours
1	Introduction, Permanent Way and Components: History and administrative setup of Indian Railways; rail gauges, permanent way – functions, requirements, sections in embankment and cutting (single/double track), electrified tracks, locomotives, wheel and axle arrangement, coning of wheels, components – rails, sleepers, ballast and formation.	8
2	Resistances and Stresses in Tracks, Hauling Capacity: Types of resistances to traction, stresses in different components of track, hauling capacity of a locomotive, tractive effort.	3
3	Joints and Fastenings: Types of joints, short welded rails, long welded rails and continuous welded rails, rail to rail and rail to sleeper fastenings, elastic fastenings.	4
4	Track Geometrics, Turnouts and Crossings: Railway alignment, vertical alignment – gradients and grade effects, horizontal alignment – horizontal curves, super-elevation, concepts of cant excess and deficiency, safe permissible speed, transition curves, widening of gauges and track clearances, points and crossings – terminologies, types of turnouts, design of turnouts, types of crossings, design of crossings.	7
5	Track Safety, High speed tracks, Urban railways: Signals classification and their functions, train operation control systems – absolute, automatic block systems, centralized train control system, ATS, interlocking of tracks – principle of interlocking, types of interlocking, high speed tracks - track	6

	requirements, speed limitations, high speed technologies, urban railway - railway systems in urban areas.	
6	Introduction, Aircraft Characteristics and Airport selection: Air transport development in India, national and international organizations in air transport, aircraft characteristics and their impact on planning of an airport, selection of site for an airport, airport obstruction, imaginary surfaces, runway orientation clam period and wind coverage.	6
7	Geometric Designs: Runway and taxiway geometric designs, exit taxiway, its design and fillet curves, runway configuration, separation clearance, design of apron and their layouts.	7
8	Airport Traffic control Aids: Visual aids, marking and lighting of runway and apron area, wind and landing direction indicator.	2
	Total	42

Suggested Books:

S. No.	Name of Books/Authors / Publishers	Year of publication
1	Chandra, S. and Agarwal, M. M., “Railway Engineering”, Oxford.	2007
2	Arora, S. P. and Saxena, S. C., “A Text Book of Railway Engineering”, Dhanpat Rai Publications.	2004
3	Mundrey, J. S., “Railway Track Engineering”, Tata Mcgraw Hill.	2000
4	Khanna, S. K., Arora, M. G. and Jain, S. S., “Airport Planning & Design”, Nem Chand and Bros.	2000
5.	Horonjeff, Robert and McKelvey, Francis X., “Planning & Design of airports’, 4 th Ed., McGraw Hill.	1993
6.	Saxena, S.C., “Airport Engineering – Planning and Design”, CBS Publishers.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **ICE-01** Course Title: **Mechanics of Laminated Composites**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge about the behavior of laminated composites at lamina as well as at laminate level and special features of composites for engineering applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Classification and characteristics of composite materials, basic terminology, uses of laminated composites, comparison of properties with traditional materials.	8
2.	Behavior of Lamina: Stress-strain relationship for anisotropic, orthotropic and isotropic materials, transformation of elastic constants, failure criteria for an orthotropic lamina, introduction to micromechanical behavior, law of mixture for $E_1, E_2, G_{12}, \nu_{12}$.	11
3.	Behavior of Laminate: Classical lamination theory, stress-strain relationship for laminate, extensional bending and coupling stiffness, different configurations and corresponding stiffness, strength of laminates, inter-laminar stresses, introduction to behavior of thin walled laminated structures.	12
4.	Computer Aided Analysis and Design: Introduction to numerical and soft computing techniques for the analysis and design of laminated composites.	11
Total		42

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication
1.	Agarwal, B.D. and Broutman, L.J., “Analysis and Performance of Fiber Composite”, John Wiley.	1980
2.	Johns, R.M., “Mechanics of Composite Materials”, Taylor & Francis.	1999
3.	Kollar, L.P. and Springer, G.S., “Mechanics of Composites Structures”, Cambridge Press.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **ICE-03** Course Title: **Global Positioning System and Its Applications**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge about the use and applications of GPS in various fields.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Fundamentals of GPS: Components of GPS, GPS receivers, reference coordinates systems – datums, geoid, ellipsoid, WGS 84 system, time, signal propagation through atmosphere-their modelling and estimation, satellite orbit.	9
2.	GPS Signals : Navigational data.	4
3.	GPS Data: Collection methods – static positioning, kinematic positioning – pseudo-kinematic and stop & go, observation planning and strategy.	3
4.	GPS Observables: Pseudo range and carrier phase, parameters estimations, data handling, cycle slip detection and correction, ambiguity resolution, GPS data processing – single, double and triple differences.	8
5.	Errors in GPS Data: Satellite geometry, errors in different segments, multipath errors, accuracy of GPS data and measures, network adjustments.	7
6.	Datum Transformation : Reduction of observation, transformation to various map projection systems.	3
7.	Differential GPS : Real time kinematic GPS, multiple reference stations, virtual reference stations.	3
8.	Engineering Applications of GPS.	5
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication
1.	Kaplan, E.D. and Hegarty, C.J., “Understanding GPS: Principles and Applications”, Artech House.	2006
2.	Leick, A., “GPS Satellite Surveying”, John Wiley.	2004
3.	Satheesh, G., “Global Positioning System and its Applications”, McGraw Hill.	2005
4.	Gunter, S., „Satellite Geodesy“, 2 nd Ed., Walterbde Gruyter.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **ICE-02** Course Title: **Digital Image Processing**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge about various techniques and applications of digital remote sensing images.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to remote sensing data analysis, spectral, spatial and radiometric resolutions, visual data interpretation, image formats, digital image and its characteristics, image processing systems.	6
2.	Initial data statistics, Histogram and Scatterplot.	2
3.	Image Preprocessing, atmospheric, radiometric and geometric corrections, image enhancement and restoration, contrast stretching-linear and non-linear.	6
4.	Noise removal, low, medium and high pass filters, other filters, multi-spectral enhancement.	5
5.	Image transformation - mathematical operators, KLT, PCA, FFT, image analysis - feature extraction, pattern recognition.	9
6.	Classification - Supervised and unsupervised techniques.	5
7.	Accuracy assessment procedures, post classification techniques.	2
8.	Data fusion, fuzzy logic, advance image processing techniques and concepts, application of digital image processing to various engineering problems.	7
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication
1.	Agarwal, C.S. and Garg, P.K., “Remote Sensing in Natural Resources Monitoring and Management”, A.H. Wheeler & Co.	2000
2.	Chandra, A.M. and Ghosh, S.K., “Remote Sensing and Geographical Information Systems”, Alpha Science.	2005
3.	Gonzalez, R.C. and Wintz, P., “Digital Image Processing”, Addison Wesley.	2000
4.	Jia, X. and Richards, J.A., “Remote Sensing Digital Image Analysis”, 3 rd Ed., Springer Verlag.	1999
5.	Mather, P.M., “Computer Processing of Remotely sensed Data”, John Wiley.	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **ICE-04** Course Title: **Theory and Applications of Geographic Information Systems**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge of the basic principles and use of GIS technology for various applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction, Geographical concepts and terminology, difference between image processing system and GIS.	3
2.	Utility of GIS, various GIS packages and their salient features, essential components of a GIS.	3
3.	Data acquisition through scanners and digitizers, methods of digitization.	3
4.	Raster and vector data, data storage, verification and editing.	5
5.	Data preprocessing, format conversion, data compression and reduction techniques, run length coding, rectification and registration, interpolation.	6
6.	Database structure – Hierarchical data, network systems, relational database, data management role of remote sensing in GIS.	6
7.	Data manipulation and analysis, spatial and mathematical operations on data, area analysis, query-based analysis, measurement and statistical modeling.	9
8.	Programming language in GIS, data output, applications of GIS for various natural resources mapping & monitoring and for engineering applications.	7
Total		42

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication
1.	Burrough, P.A. and McDonnell, R.A., “Principles of Geographic Information for Land Resources Assessment”, Oxford University Press.	1998
2.	DeMers, M.N., “Fundamentals of Geographic Information System”, 3 rd Ed., John Wiley.	2005
3.	Legg, C.A., “Remote Sensing and Geographic Information System”, John Wiley.	1999
4.	Chandra, A.M. and Ghosh, S.K., “Remote Sensing and Geographical Information Systems”, Alpha Science.	2005
5.	Maguire, D.J., Batty, M. and Goodchild, M. (Eds.), “GIS, Spatial Analysis and Modelling”, ESRI Press.	2005