Course outline and Syllabus for the proposed

Master of Technology

in

Earth System Science and Engineering

Department of Civil Engineering

Indian Institute of Technology Guwahati

Guwahati 781 039

Assam

Premise

The motivation for this programme comes from the accelerated demand of expert manpower to cater the need of safe infrastructural development and optimal resource utilization of North East. Civil Engineering department, being closely related to these aspects is already having a research focus in this direction. Thus being inspired by the institute mandate to cater the need of North East region, the department has come forward to start the specialization initially as a post graduate program within the department, which eventually may grow as a centre and then to a full-fledged department.

The objective of this unique programme in Earth System Science and Engineering is to produce skilled personnel's with a knowledge-base, integrating scientific and engineering approaches in Geosystem management. Such a training programme is especially relevant, considering the global requirement of trained professionals working in non-renewable energy resources. North-eastern region of India is in a seismic zone that demands close monitoring of geophysical parameters, as well blessed with un-explored and systematically quantified natural resources. Impetus will therefore be on various spheres of earth system and the challenges imposed by human intervention on the system.

The main focus of the program will be on various spheres of earth system and the challenges imposed by human intervention on the system. In the backdrop of accelerated infrastructure development for national growth, growing incidences of geo hazards and natural uncertainties such as climate change has necessitated systemic understanding of earth systems in order to build future infrastructures pragmatically, and seek sustainable solutions for hazard related uncertainties. Therefore various thrust areas are geohazards and risk evaluation, optimized utilization of natural and mineral resources including oil and gas, restoration of contaminated sites, management and mitigation of processes related to the geo-environment etc. An interdisciplinary systems approach will constitute the core of this programme, combining engineering, geology, and geophysics. The focus will be on addressing complex real-world problems such as characterization, prediction and remediation by generating early warning system for natural hazards. Emphasis will also be on growing geological infrastructure challenges being manifested at an increasing rate than ever before in complex terrains like those of the Himalayas.

Earth system science, as an emerging discipline has been widely accepted by the academic community world-wide and was greatly emphasized by our former President, Dr. A P J Abdul Kalam. Now, there is a growing realization that broad and in-depth understanding of different geophysical systems on the surface and subsurface of the earth operates in an interconnected manner, and hence is important to build safe futuristic infrastructure. Almost all aspects of civil engineering share interface with earth systems and processes. The proposed programme has been designed to lay emphasis on all geological aspects of infrastructure vis-à-vis the materials and processes that they interact with. The proposed Master of Technology programme on Earth System Science and Engineering will offer a set of core subjects covering both the broad and critical issues, integrating geo systems and processes for sustainable development. The programme will also provide opportunities to take up an in-depth thesis project for developing deeper understanding and expertise in a relevant field connecting established knowhow, emerging concerns and futuristic solutions.

Graduates of this program will:

- Apply knowledge of mathematics, geological sciences and engineering in seeking both immediate and long term solutions to relevant problems
- Design and conduct experiments and engineering tests, as well as analyze and interpret geologic data for producing purposeful knowledge and applications
- Create a system, component, process or model to meet desired needs
- Identify, formulate, and solve problems with engineering and geological aspects
- Understand professional and ethical responsibilities in the practice of geo-engineering and areas like hydrogeology
- Appreciate the impact of engineering and geological solutions in a global and societal context
- Understand contemporary issues and the ways they affect the practice of geo-engineering and hydrogeology including contaminant fate and transport.

- Use the techniques, skills, and modern engineering and geological tools, often in conjunction, including computer applications that are appropriate for good engineering and geologic practice

- Be employed with geo-environmental sector, sustainable infrastructure, natural resource management, hydropower and similar relevant industries and companies in addition to concerned government agencies.

Number of Seats for the programme: 10(Ten)

Resources and Facilities Required

Besides leveraging on existing academic infrastructure and facilities of the Civil Engineering Department, additional resources and facilities would be required for the proposed programme.

- **Space:** Additional laboratory space for this programme will be required in addition to the new engineering geology lab in the Annex building of Civil Engineering. The current engineering geology lab located in N block should be retained with Civil Engineering Department. In order to start the program, the engineering geology lab located in N block and the new lab in Annex will be sufficient.
- **State of the Art laboratory:** The laboratory will have analytical equipment, computing facilities with necessary hardware and software.

Specific Requirements

- **Instruments**

1. Automated Thin section lab (in house)
2. Petrographic microscope (5) (in house)
3. Ore microscope (2) (in house)
4. AAS
5. UV-VIS-NIR spectrometer

6. FTIR Spectrometer

Computational Facility

Softwares and hardware components: Computers - 10(Ten) Nos.

1. Geostatistical software
2. Geochemical software such as Aquachem.
3. Geophysical software such as Rockworks, Rock Science, ROCK Triaxial, PETREL, GEOFRAME
4. Modeling software for hydrology, atmosphere, etc.
5. Field equipment such as compass, hammer, drilling machine would be required for conducting the laboratory classes and dissertation projects.
6. GIS and Remote Sensing software such as ARC-GIS, ENVI, ERDAS

Shared instruments (will use existing facilities)

1. Porosity-permeability measurement lab
2. Ground Penetrating Radar GPR
3. LIDAR Terrestrial Scanner
4. Electrical Resistivity Meter
5. Spectroradiometer
6. Sounding Instrument
7. SEM
8. XRD
9. XRF
10. Mass Spectrometer (GC-MS and ICP-MS)
11. Geophysical instruments for resistivity survey, seismic survey

Budget for Laboratory:

Year	2015-2016 (in lakhs)	2016-2017 (in lakhs)	2017-2018 (in lakhs)	2018-2019 (in lakhs)	2019-2020 (in lakhs)
Wet Chemistry	5	-	-	-	-
Computational Lab	10	10	10	30	25
*Thin Section Lab	-	30	5	-	-
*Advanced Instrumentation Lab	-	-	30	50	80
Total	15	40	45	80	105

*Advanced Instrumentation lab will be developed with the support from Ministry of Earth Science, GOI, through funding for Research and Capacity building program.

Annexure-120/4(e) contd…….

- **Manpower:** A minimum of four dedicated faculty members will be required for running the programme. In view of the existing faculty members' areas of expertise, new faculty members who specializes in at least one of the areas such as geo-dynamic modeling, Isotope geochemistry, geophysics with specialization in handling seismic data would be required. Additional staff (min 2) will be required to manage the lab and conducting practical classes. In addition to the above, specific staff (1) will be required for rock cutting and polishing.

<u>Eligibility</u>

For admission a candidate must satisfy one of the following criteria:

1. Four year Bachelor's degree in Civil Engineering, Petroleum Engineering, Mining Engineering, Mineral Engineering, Geoscience Engineering, Engineering Physics (or equivalent), Engineering Mathematics (or equivalent) with a minimum CPI of 6.5 or 60% of marks or 1st class.
2. Master of Science degree in Geology (or equivalent), Geophysics (or equivalent), Physics with a minimum of 6.5 or 60% of marks or 1st class.
3. Master of Science degree in Mathematics, Chemistry and allied areas in natural sciences with a minimum CPI of 7.0 or 65% marks.

<u>Selection Procedure</u>

For admission in the programme, besides the above qualification, a candidate must have a valid GATE score. Selection will be primarily based on GATE score, to be supplemented by a written test and/or interview followed by counseling. B.Tech graduates from IIT with a minimum CPI of 7 and above are not required to have GATE score to appear for interview. Selection will be based upon evaluation of the suitability of the candidate for the programme.

The Course Outline and the syllabus for the new courses proposed for the programme are appended.

Annexure-120/4(e) contd…….

M. Tech. in Earth System Science and Engineering

SEMESTER - 1

Course No.	Course Name	L – T – P – C
CE 591	Earth System Dynamics	3 – 0 – 0 – 6
CE 592	Exploration Geoscience	3 – 0 – 0 – 6
CE 593	Advanced Remote Sensing	3 – 0 – 2 – 8
CE XXX	Elective I	3 – 0 – 0 – 6
CE XXX	Elective II	3 – 0 – 0 – 6
		15 –0 – 2 – 32

SEMESTER – 2

Course No.	Course Name	L – T – P – C
CE 594	Geohazard Science and Engineering	3 – 0 – 0 – 6
CE 595	Advanced Techniques in Geoscience	2 – 0 – 2 – 6
CE XXX	Elective III	3 – 0 – 0 – 6
CE XXX	Elective IV	3 – 0 – 0 – 6
CE XXX	Elective V	3 – 0 – 0 – 6
		14 –0 – 2 – 30

SEMESTER – 3

Course No.	Course Name	L – T – P – C
CE 598	M Tech Project – Phase I	0 – 0 – 24 –24
		0 – 0 – 24 –24

SEMESTER – 4

Course No.	Course Name	L – T – P – C
CE 599	M Tech Project – Phase II	0 – 0 – 24 –24
		0 – 0 – 24 –24

LIST OF ELECTIVES

Course No.	Course Name	L – T – P – C
Elective I		
CE 601	Numerical Methods	3 – 0 – 0 – 6
CE 602	Optimization Methods	3 – 0 – 0 – 6
CE 513	Statistical Methods in Civil Engineering	3 – 0 – 0 – 6
Elective II		
CE 635	Geodesy and Mapping	3 – 0 – 0 – 6
CE 636	Geostatistics	3 – 0 – 0 – 6
CE 501	Continuum Mechanics	3 – 0 – 0 – 6
CE 503	Structural Dynamics	3 – 0 – 0 – 6
CE 554	Advanced Fluid Mechanics	3 – 0 – 0 – 6
CE 563	Flow and Transport Processes in Fractured Media	3 – 0 – 0 – 6
CL613	Computational Fluid Dynamics	3 – 0 – 0 – 6
CE 637	Petroleum Geology	3 – 0 – 0 – 6
Elective III		
CE 638	Structural Geology	3 – 0 – 0 – 6
CE 639	Geochemistry	3 – 0 – 0 – 6
CE 640	Advanced Image & Spectral Analysis	3 – 0 – 0 – 6
CE 652	Precision Remote Sensing	3 – 0 – 0 – 6
CE 653	Advanced Hydrogeology	3 – 0 – 0 – 6
CE 646	Rock Mechanics	3 – 0 – 0 – 6
CE 654	Petrophysics	3 – 0 – 0 – 6
CE 642	Subsurface Investigation and Instrumentation	3 – 0 – 0 – 6
Elective IV		
CE 655	Underground Exploration	3 – 0 – 0 – 6
CE 557	Environmental Hydrology	2 – 0 – 2 – 6
CE 564	Stochastic Hydrology	3 – 0 – 0 – 6
CE 565	Introduction to Multiphase Flow	3 – 0 – 0 – 6
CE 568	Environmental Management of Water Resources	3 – 0 – 0 – 6
CE 572	Pollution and Contaminant Flux in Water Environment	3 – 0 – 0 – 6
CE 552	Water Resources Systems Analysis, Planning &Mgt	3 – 0 – 0 – 6

CL633	Applied Statistical Thermodynamics	3 – 0 – 0 – 6
CE 567	Sediment Dynamics in Fluvial Systems	2 – 0 – 2 – 6

Elective V

CE 657	Engineering Seismology	3 – 0 – 0 – 6
CE 658	Earth System Engineering	2 – 0 – 2 – 6
CE 606	Earthquake Engineering	3 – 0 – 0 – 6
CE 659	Climate Change: Causes, Effects and Mitigation	3 – 0 – 0 – 6
CE 660	Landslide Engineering	3 – 0 – 0 – 6
CE 666	Advanced Geological Engineering	3 – 0 – 0 – 6

Detailed Syllabus for M.Tech. in Earth System Science and Engineering

CE 591 Earth System Dynamics (3-0-0-6)

Course Content:

Definition and scope of earth system sciences; fundamental concepts of the five spheres (lithosphere, hydrosphere, atmosphere, biosphere and cryosphere); interactions between the five spheres; carbon cycle; hydrologic cycle; fundamental geoscience concepts; functional components; earth system: the physical and chemical processes; unifying concepts of geosciences to examine surface and internal processes in the earth including weathering; plate tectonics, earthquake; volcano; orogeny; palaeoclimate.

Texts/ References:

1. Brian, J. S., Barbara, W.M., 2010. The Blue Planet: An Introduction to Earth System Science, 3rd Edition, Wiley.
2. Ernst, W.G., 2000. Earth Systems: Processes and Issues, Cambridge University Press.
3. Sarah, E., Cornell, I., Prentice, C., Joanna, I.H., Catherine, J.D., 2012. Understanding the Earth System Global Change Science for Application, Academic Press.
4. Jacobson, M., Charlson, R., Rodhe, H., Orians, G., 2000.Earth System Science: From Biogeochemical Cycles to Global Changes, Elsevier.
5. Ehlers, E., Krafft, T., 2006. Earth System Science in the Anthropocene, Springer.

CE 592 Exploration Geosciences (3-0-0-6)

Course Content:

Distribution of ore deposits in space and time; stages of exploration and objectives; prospecting criteria and selection of areas for exploration during reconnaissance and initial follow-up; introduction to geophysical exploration techniques, gravity and magnetic methods, principles and methods of gravity and magnetic prospecting, geological setting and prospecting criteria for important deposits; petroleum resources, gold deposits, massive sulfide deposits, porphyry copper deposits; underground sampling and calculation of blocked reserves; seismic

Annexure-120/4(e) contd…….

exploration theory and geometry of seismic waves, seismic sources and equipment, reflection and refraction field method, seismic stratigraphy, seismic interpretation, hydrocarbon indicators, resistivity methods; well logging techniques and data processing, applications and limitations of various geophysical techniques in solving geological, hydrogeological, geotechnical, and environmental problems, with an emphasis on mineral and hydrocarbon exploration.

Texts/References:

1. Moon, C.J., Whateley, M.K., Evans, G., 2006. Introduction to Mineral Exploration, Blackwell Science, Oxford.
2. Telford, W.M., Geldart, L.P., Sheriff, R.E., 1990. Applied Geophysics, Cambridge University Press, Cambridge.
3. Peters, W.C., 1987. Exploration and Mining Geology, 2nd Edition, John Wiley & Sons, New York.
4. Chugh, C.P., 1992. High Technology in Drilling and Exploration, Oxford & IBH, New Delhi.
5. Sheriff, R.E., Geldart, L.P., Exploration Seismology, Cambridge University Press, Cambridge.

CE 593 Advanced Remote Sensing (3-0-2-8)

Course Content:

Fundamentals of remote sensing; Interaction of EMR with the atmosphere and the earth surface; types of remote sensor and platforms; types of resolution; active and passive remote sensing; introduction to panchromatic, multispectral and hyperspectral data; basics of optical and microwave remote sensing.

Hyperspectral remote sensing: causes of absorption feature in the spectra, hyperspectral image and spectral measurement techniques (in laboratory, field and space), atmospheric correction techniques, pre-processing of hyperspectral images (geometric correction, data dimensionality reduction and noise whitening), processing of measured lab/field spectra; endmember extraction; sub-pixel classification and information extraction; Thermal Remote Sensing: introduction to thermal remote sensing, available spaceborne thermal sensors, Temperature-Emissivity Separation (TES) techniques, information extraction, advance quantitative analyses of thermal imagery and accuracy assessment (confusion matrix); application of quantitative hyperspectral and thermal remote sensing techniques in earth and planetary exploration, and civil engineering.

Texts/References:

1. Van-dr-Meer, F., De Jong, S., 2006. Imaging spectrometry: Basic principles and prospective applications (The Netherlands: Springer Publishers), 451p.
2. Rencz, A.N., 2008. Remote Sensing for the Earth Sciences, Manual of Remote Sensing, 3, ASPRS, 703p.
3. De-Jong, Steven, M., Van der Meer, F.D., 2004. Remote Sensing Image Analysis: Including the Spatial Domain: Including the Spatial Domain, 5, Springer, 359p.
4. Claudia, K., Stefan, D., 2014. Quantitative Remote Sensing in Thermal Infrared, 11, Springer, 281p.

CE 594 Geohazards Science and Engineering (3-0-0-6)

Course Content:

Introduction to risks and geohazards; different types of hazards: natural disasters, landslides, tornados, earthquakes, acute and chronic health effects; long-term societal effects due to environmental change: sea level rise and global warming; physical principles of hazardous phenomena and quantitative methods for hazard assessment; methods of risk mitigation; risk control and management; geological hazard management, hazard forecasting system, and applications.

Texts/ References:

1. Abbott, P.L., 2013. Natural Disasters, 9^{th} Edition, McGraw Hill Education, 512p.
2. Porter, M., Jakob, M., Savigny, K.W., 2015. Geohazard Risk Management for Linear Facilities, 310p, Springer
3. Nicholas, C., 1994. Geohazards: Natural and Human, Prentice Hall.

CE 595 Advanced Techniques in Geoscience (2-0-2-6)

Course Content:

Generation of structural geology and lithology map; interpretation of subsurface geology from geological data; preparation and interpretation of gravity and magnetic anomaly maps; preparation of geological maps from aerial photographs; preparation of geological maps and lineaments maps from satellite imagery; geophysical and geochemical processes; study on interactions of various processes by using observations from field data and remote sensing data operation of analytical instruments such as mass spectrometers; xrf; spectrophotometers; experimental design; standardization and calibration; analysis and integration of geological, geochemical and geophysical data; resistivity survey and interpretation of resistivity data; seismic data interpretation; well logging and core data analysis and interpretation for petroleum reserves; calculation of ore reserves from given geological map and data from ore microscopy and fluid inclusion; calculation of grade and averaging of assay value and demarcation of ore bearing zones; preparation and interpretation of geochemical anomaly and maps.

Texts/References:

1. Williams, H., Turner, F.J., Gilbert, C.M., 1954. Petrography-An Introduction to the Study of Rocks in Thin Sections, W.H. Freeman and Company.
2. Khandpur, R.S., 2006. Handbook of Analytical Instruments, 2nd Edition Tata McGraw-Hill Publishing Company Ltd.
3. S.N., Pandey, 1987. Principles and Applications of Photogeology, Wiley Eastern.
4. Telford, W.M., L.P., Geldart, Sheriff, R.E., 1990. Applied Geophysics, Cambridge University Press.
5. Robinson, E.S., Coruh, C., 1988. Basic Exploration Geophysics, John Wiley & Sons.

ELECTIVE COURSES

Elective I

CE 601 Numerical Methods (3-0-0-6)

Course Content:

Linear equations and Eigen value problems; Accuracy of approximate calculations; Nonlinear equations; interpolation; differentiation and evaluation of single and multiple integrals; initial and boundary value problems by finite difference method; Newton's method, variation and weighted residual methods; introduction to finite element methods; fundamental of statistical distribution.

Texts/References:

1. J. B. Scarborough, Numerical mathematical analysis, Oxford & IBH Publishing CO Pvt., 2000
2. K. K. Jain, S. R. K Iyengar and R. K. Jain Numerical methods-problem and solutions, Wiley Eastern limited, 2001
3. R.W. Hamming, Numerical methods for scientist and engineers, McGraw Hill, 1998.
4. J. H. Mathews and K.D. Fink, Numerical methods using MATLAB, Pearson Education, 2004
5. J. Hayter, Probability and statistics, Duxbury, 2002.

CE 602 Optimization Methods (3-0-0-6)

Course Content:

Basics of engineering analysis and design, need for optimal design, formulation of optimal design problems, basic difficulties associated with solution of optimal problems, classical optimization methods, necessary and sufficient optimality criteria for unconstrained and constrained problems, Kuhn-Tucker conditions, global optimality and convex analysis, linear optimal problems, Simplex method, Introduction to Karmarkar's algorithm; numerical methods for nonlinear unconstrained and constrained problems, sensitivity analysis, linear post optimal analysis, sensitivity analysis of discrete and distributed systems; introduction to variational methods of sensitivity analysis, shape sensitivity, introduction to integer programming, dynamic programming, stochastic programming and geometric programming, introduction to genetic algorithm and simulated annealing.

Texts/References:

1. K. Deb., Optimization for Engineering Design: Algorithms and Examples, PHI Pvt Ltd., 1998.
2. J. S. Arora, Introduction to Optimum Design, McGraw Hill International Edition, 1989.
3. R. T. Hafta and Z. Gurdal., Elements of Structural Optimization, Third Revised and Expanded Edition. Kluwer Academic Publishers 1996.

CE 513 Statistical Methods in Civil Engineering (3-0-0-6)

Course Content:

Charts and diagrams; measures of central tendency and measures of dispersions and their applications in civil engineering; percentile ranks and percentiles; concept of standardization; applications of scatter plots; covariance; correlation coefficients and their properties in field data; curve fitting and least square techniques and their use in the experimental methods in civil engineering; concept of regressions; regression curve in bivariate frequency distributions; introduction to probability and set theory; probabilistic measures; conditional probability and Bayes' theorem; discrete and continuous random variables; probability density functions; probability distributions of single and multiple random variables; discrete & continuous distributions; chi-square test; Kolmogorovsmirnov test; analysis of variance; conditional distributions and independence; expectations and moments and their applications in random vibrations and other fields of Civil engineering; random processes and their properties; some important random processes and their applications in Civil engineering.

Texts/References:

1. Douglas, C., Montgomery and George C., Runger, 2009. Applied Statistics and Probability for Engineers, Wiley India Pvt. Ltd.
2. David, A., 2010. Statistics: From Concept to Practice, Lynne Rienner Publishers Inc.
3. Bendat, S., and Piersol, A.G., 2010. Random Data: Measurements and Analysis, John Wiley and Sons.
4. Mendenhall, W., Sincich, T., Statistics for Engineering and the Sciences, Prentice-Hall.
5. Devore, J.L., 2009. Probability and Statistics for Engineering and the Sciences, Brooke & Cole.

Elective II

CE 635 Geodesy and Mapping (3-0-0-6)

Course Content:

Astronomy and Geometric Geodesy: Celestial Sphere, Definition of terms in Astronomy, Celestial coordinate systems, Variations in Celestial coordinates; Precession and Nutation; Time systems--Sidereal time, Ephemeries time, Atomic time; Rotational Time systems: UT0, UT1, UT2, CIO and Polar motion, Earth Rotation parameters and Leap second; Coordinate Systems in Geodesy, Geodetic reference systems: ICRF and ITRF, Datums-Horizontal & Vertical, GRS-80, WGS-84; Transformation of Coordinates from one datum to another; Mean Sea level, Geoid and MSL in India; Geometry of Ellipsoid, Level Surface and Plumb Line, Deflection of vertical, Geoidal Separation, Natural Coordinates, Astrogeodetic deflection; satellite geodesy: Introduction to Satellite Geodesy, Keplerian Motion, Geometry of ellipse, Kepler ellipse in space; Introduction to GNSS satellite systems, Satellite Laser ranging, Satellite Altimetry; Map Projection: Introduction to Map projection, Purpose and methods of Map projection and their classification; Conformal Map projections: LCC and Transverse Mercator Projections; Indian Grid System and UTM.

Texts/References:

1. Bomford, G., 2010. Geodesy, Oxford University Press.
2. Vanícek, P., Krakiwsky, E.J., 1987. Geodesy: The concept, 2nd Edition, Elsevier Science.
3. Torge, W., 2001. Geodesy, 3rd Edition, deGruyter, Berlin.
4. Berlin, P., 2004. The Geostationary Applications Satellite, Cambridge Univ. Press.
5. Betz, J.W., 2015. Satellite-Based Navigation and Timing: Engineering Systems, Signals, and Receivers, Wiley-IEEE Press.

CE 636 Geostatistics (3-0-0-6)

Course Content:

Introduction to probability, statistics and set theory; observations and mathematical model, precision and accuracy, rejection of observations, weights and cofactors, correlation and covariance, propagation of errors and variance-covariance; Least squares adjustment computations; Sequential processing and Kalman Filtering, Variance-covariance of adjusted data, error ellipse and error ellipsoid; Statistical analysis of adjusted data; methods of interpolation: Variogram, Semivariogram, Kriging; Applications of adjustments computations for geospatial data analysis.

Texts/References:

1. Douglas, C., Montgomery and George, C.R., 2009. Applied Statistics and Probability for Engineers, Wiley India Pvt. Ltd.
2. David, A., 2010. Statistics: From Concept to Practice, Lynne Rienner Publishers Inc.
3. George, T., Geoff, B., 2006. Intelligent Positioning: GIS-GPS Unification, John Wiley & Sons.

4. Benenson, I., Torrens, P., 2004. Geosimulation: Automata-Based Modeling of Urban Phenomena, John Wiley & Sons.
5. Kelly, R.E.J., Drake, N.A., Barr, S.L., 2004. Spatial Modelling of the Terrestrial Environment, John Wiley & Sons.

CE 501 Continuum Mechanics (3-0-0-6)

Course Content:

Basic concepts of the theory of continuous media; introduction to tensor algebra; Elementary introduction to Cartesian tensors and tensor operations, theory of stresses; infinitesimal and finite strains; strain-displacement relationships; compatibility; stress-strain relationships ; plane stress and plane strain case; stress function approaches; plane problems in Cartesian and polar coordinates; spatial (Eulerian) and material (Lagrangian) description of motion of deformable bodies, boundary value problem in elasticity elements of plasticity; yield criteria; flow rule and hardening; strain displacement relationship, strain rate tensor, time rate of change of volume and line integrals, stress tensor, continuity and equilibrium equations, constitutive equations, boundary value problems, Navier equations, conservation laws, yielding of material, plastic flow theory, derivation of Navier-Stoke's equation and its applications.

Annexure-120/4(e) contd…….

Texts/References:

1. Lai, W.M., Rubin, D., Krempl, E., 1993. Introduction to Continuum Mechanics, Pergamon Press Ltd.
2. Chandrasekharaiah, D.S., Debnath, L., 1994. Continuum Mechanics, Prism Books Pvt. Ltd., Bangalore.
3. Chatterjee, R., 1999. Mathematical Theory of Continuum Mechanics, Narosa Publishing House.
4. H., Shames, and F.A., 1992. Cozzarellie, Elastic and Inelastic Stress Analysis, Prentice Hall New Jersey.
5. Spencer, A.J.M., 1980. Continuum Mechanics, Dover Publications.

CE 503 Structural Dynamics (3-0-0-6)

Course Content:

SDOF systems: Equations of Motion, Free vibration, damping, Forced vibrations under harmonic, impulse and general loadings, Response spectrum Generalized SDOF systems: Rigid body distributed mass and stiffness systems; MDOF Systems: Dynamic properties, modal damping, classical damping, modal superposition methods; Numerical methods in dynamics: Eigen value analysis, direct integration scheme: Continuous systems: Equations of motion, Hamilton's principle, Lagrangian formulation, Free and force vibration scheme, Wave propagation; Introduction to Random vibration: Random variables, Random process, moment and characteristic function, spectral analysis, response to random excitation; Application of structural dynamics in the design of block and frame foundation.

Texts/References:

1. Clough, R.W., Penzien, J., 1993. Dynamics of Structures, Second edition, McGraw Hill international edition.
2. Mario, P., 1987. Structural dynamics, CBS Publishers.
3. Chopra, A.K., 1987. Dynamics of structures: Theory and applications to earthquake engineering, PHI Ltd.
4. Rao, K., 1998. Vibration analysis and foundation dynamics, Wheeler.
5. Siniu, E., Scanlan, R.H., 1997. Wind effects on structures: fundamentals and applications to design, John Wiley and Sons.

CE 554 Advanced Fluid Mechanics (3-0-0-6)

Course Content:

Elementary introduction to Cartesian tensors and tensor operations; notion of a continuum and definition of fluid, scalar and vector fields; spatial (Eulerian) and material (Lagrangian) description of motion of deformable bodies, rotation and vorticity; strain rate tensor; time rate of change of volume and line integrals; Reynold's transport theorem; stream function; irrotational flow and velocity potential, internal, external and surface contact forces, stress tensor, continuity and equilibrium equations, constitutive equations, derivation of Navier-Stoke's equation; plane Poiseuille flow and Couette flow; Hagen-Poiseuille flow; Stokes' flow; slow flow and Hele-Shaw flow; flow in convergent-divergent channels; introduction to laminar flow; Blasius equation; Karman momentum equation; description of turbulent flow; Kelvin-Helmholtz instability; mean flow equations; Prandtl's mixing length; turbulent Poiseuille flow; jets and wakes.

Annexure-120/4(e) contd…….

Texts/References:

1. Ligett, J.A., 1994. Fluid Mechanics, McGraw-Hill International Editions.
2. Batchelor, G.K., 2005. An Introduction to Fluid Mechanics, Cambridge University Press, London.
3. Shames, L.H., 1992. Mechanics of Fluids, McGraw-Hill.
4. Chatterjee, R., 1999. Mathematical Theory of Continuum Mechanics, Narosa Publishing House.
5. Chung, T.J., 1988. Continuum Mechanics, Prentice Hall.

CE 563 Flow and Transport Processes in Fractured Media (3-0-0-6)

Course Content:

Fractured rock systems; hydrogeologic characterization methods; channeling; fracture network; point and non-point sources of pollutants; conservative and reactive solute transport; fracture flow and transport models.

Texts/References:

1. Adler, P.M., Thovert, J.F., 1999. Fractures and Fracture Networks, Kluwer Academic Publishers, Dordrecht.
2. Committee on Fracture Characterization and Fluid Flow, Rock Fractures and Fluid Flow: Contemporary Understanding and Applications, National Academy Press, 1996.
3. Gelhar, L.W., 1993. Stochastic Subsurface Hydrology, Prentice-Hall, Englewood-Cliffs, NJ, USA.

4. Committee on Source Removal of Contaminants in the Subsurface, Contaminants in the Subsurface: Source Zone Assessment and Remediation, National Academy Press, 2004.

CE 637 Petroleum Geology (3-0-0-6)

Course Content:

Origin and composition of petroleum and natural gas, geology of petroleum basins; petroleum system: source rocks, reservoir rocks and traps; geographic and stratigraphic distributions of oil and gas; Oil migration; structural and tectonic aspects of petroliferous basins; types of petroliferous basins and their relation to hydrocarbon potential; Methods and techniques for petroleum exploration; Sub-surface geological methods and brief idea about geologic interpretations of seismic data; well-logs; drilling techniques; production and development geology.

Texts/References:

1. North, F.K., 1985. Petroleum Geology, Allen & Unwin, London.
2. Bastia, R., Radhakrishna, M., 2012. Basin Evolution and Petroleum: Prospectivity of the Continental Margins of India, Elsevier.
3. Hunt, J.M., 1996. Petroleum Geochemistry and Geology, 2nd Edition, W.H., Freeman, San Fransisco.
4. Tissot, B.P., Welte, D.H., 1984. Petroleum Formation and Occurrence, 2nd Edition, Springer-Verlag, Berlin.
5. Selley, R.C., 1997. Elements of Petroleum Geology, 2nd Edition, Academic Press, London.

Elective III

CE 638 Structural Geology (3-0-0-6)

Course Content:

Dynamic and kinematic analyses of rocks in two dimensions, stress and strain; Folds: classification, mechanism of folding; Biot's law; strain within buckled layer; similar fold and shear fold; kink bands; chevron folds and conjugate fold; cleavage; lineation; boudinage; deformation of linear structures by flexural slip folding and shear folding; deformation of planar structures by flexural slip folding and shear folding; superimposed folding: Type 1, 2 and 3 interference pattern; faults and ductile shear zone.

Texts/References:

1. Ramsay, J.G., 1967. Folding and fracturing of rocks, McGraw Hill.
2. Ghosh, S.K., 1993. Structural Geology–Fundamentals and modern development, Pergamon.

3. Ramsay, J.G., Huber, M.I., 1987. The techniques of modern structural geology, Folds and Fractures, Academic Press, London.
4. Fossen, H., 2010. Structural Geology.
5. Richard, W., Allmendinger, N.C., 2011. Structural Geology Algorithms: Vectors and Tensors, Cambridge University Press.

CE 639 Geochemistry (3-0-0-6)

Course Content:

Chemical composition of the Earth and its constituent reservoirs; meteorite evidence; elementary statistics for geochemistry; major, minor and trace elements including rare earth elements; element partitioning between minerals and melts; oxide-element conversions; radioactivity and geochronology; chemical and isotopic fractionation; application of Rb-Sr and Sm-Nd isotope geochemistry to rock dating, petrogenesis, and crust-mantle evolution; mixing phenomena in elements and isotopes; laws of thermodynamics; internal energy, heat capacity, enthalpy and entropy; Gibbs free energy and chemical potential; fugacity and activity; Raoult's law and Henry's law; ideal and non-ideal solutions aqueous solutions and solubility equilibria; activities of ionic species; construction of Eh-pH diagrams.

Texts/References:

1.Anderson, G.M. Thermodynamics of Natural Systems, Cambridge University Press, 2005.
2.Drever, J.I. The Geochemistry of Natural Waters, 3rd Edn., Prentice Hall, 1997.
3.Faure, G. Principles of Isotope Geology, 2nd Edn., John Wiley, 1986.
4.Mason, B. and Moore, C. B. Principles of Geochemistry, 4th Edn., John Wiley, 1982.
5.Wood, B.J. and Fraser, D.G. Elementary Thermodynamics for Geologists. Oxford, 1977.

CE 640 Advanced Image and Spectral Analysis (3-0-0-6)

Pre Requisite: CE 593 : Advance Remote Sensing

Course Content:

Fundamentals of hyperspectral remote sensing; origin of spectral absorption features; characteristic absorption features of natural and manmade materials; hyperspectral sensors (present and future); atmospheric correction techniques; data dimensionality reduction (PCA, MNF, ICA); digital image enhancement and filtering techniques.

Introduction to spectroradiometers, calibration of spectroradiometers, spectral acquisition in controlled environment, up-scaling of lab/field scale information to the satellite scale, characterization of measured spectra, fundamentals of linear and non-linear spectral deconvolution;

spectral unmixing using library and field spectra; Extraction of image “Endmembers” in N-dimension space, characterization of derived Image Endmembers using spectral repository, sub-pixel classification using image derived Endmembers and lab measured spectra (Binary Encoding, Spectral Angle Mapper, Linear Unmixing, Mixture Tuned Matched Filtering), and accuracy assessment; Case studies: Application of imaging spectroscopy.

Texts/References:

1. Van-der-Meer, F., De Jong, S., 2006. Imaging spectrometry: Basic principles and prospective applications (The Netherlands: Springer Publishers), 1–451.
2. Rencz, A.N., 2008. Remote Sensing for the Earth Sciences, Manual of Remote Sensing, 3, ASPRS, 703p.
3. De-Jong, S.M., Van-der-Meer, F.D., 2004. Remote Sensing Image Analysis: Including the Spatial Domain: Including the Spatial Domain, 5; Springer, 359p.

CE 652 Precision Remote Sensing (3-0-0-6)

Course Content:

Global Positioning Systems; Surveying with GPS; Planning and field observations; GIS and GPS integration.

LiDAR: Physics and spectral characteristics of laser and its interaction with objects; Airborne Altimetric LiDAR: principle; topographic and bathymetric LiDAR; multiple return; full wave digitization; components of a LiDAR system, calibration and flight planning; LiDAR geolocation models; Accuracy and error propagation; error analysis and removal; data classification techniques; LiDAR data integration with spectral data; LiDAR applications; Photogrammetry: Metric and non-metric cameras; geometry of photographs; heights and tilt distortions; rectification and orthophotographs; stereoscopy, parallax equation and stereo measurements for height determination; orientation: interior, exterior, relative, and absolute;mathematical model relating images, model and object space; image matching techniques (signal and feature-based, relational, cross-correlation and least squares

matching); strip and block triangulation and adjustment;automatic DTM and orthophoto production, flight planning.

Texts/References:

1. Maune, D.F., 2002. Digital elevation model technologies and applications: The DEM user’s manual, Manual of Remote Sensing: ASPRS.
2. Moffit, F.H., Mikhail, E.M., 1980. Photogrammetry, 3rd Edition, New York: Harper & Row.
3. Wolf, P.R., 1982. Elements of Photogrammetry, 2nd Edition, McGraw-Hill.
4. Linder,Wi, 2006. Digital Photogrammetry, Springer-Verlag Berlin Heidelberg.
5. Mikhail, E.M., Bethel, J.S., McGlone, J.C., 2001. Introduction to Modern Photogrammetry, John Wiley & Sons.

CE 653 Advanced Hydrogeology (3-0-0-6)

Course Content:

Basic concept of hydrology and hydrogeology; Water Cycle; Water balance and hydrological processes; environment and water; Physical, chemical and biological quality of natural surface water and groundwater; Organic and inorganic pollutants in water and wastewater; water quality criteria for drinking, municipal, industrial, agricultural, recreational, wildlife and aquatic organisms; specific refractory substances in water and its impact on water usage; effluent discharge standards; The continuum approach to transport in subsurface hydrology; Darcy's law and its generalization; flow through saturated and unsaturated porous formations; well hydraulics; analysis of pumping test data; groundwater recharge; water logging and salinity; infiltration and exfiltration from soils in presence and absence of a water table; modeling contaminant transport porous media; dispersion, adsorption and decay, volatilization; applications of numerical models in hydrogeology; model conceptualization, discretization and calibration, initial and boundary conditions, use of Dirichlet and Neumann boundaries, modeling strategy, pitfalls and limitations; Management of groundwater resources, development of management model, incorporation of simulation model with the optimization model; Applications : pollution control, mining and construction dewatering, saltwater intrusion, wetland protection from dewatering.

Texts/References:

1.Chow, V.T., Maidment, D.R., Mays, L.W., Applied Hydrology, McGraw Hill, 1988.
2.Todd, D.K., Ground Water Hydrology, Wiley, New York, 1998.
3.Mays, L.W., Water Resources Engineering, John Willey and Sons, US, 2001.
4.Haan, C. T., Statistical Methods in Hydrology, Iowa State University Press, 1977.
5.Maidment, D. R., Handbook of Hydrology, McGraw Hill, 1993. 30

Annexure-120/4(e) contd…….

CE 646 Rock Mechanics (3 0 0 6)

Course Content:

Geological formation of rocks, Structural Geology, Classification of rocks, Physico-mechanical properties of rocks, Laboratory and field tests, Stress-strain behaviour, Failure criteria for intact rock and rock masses, Fracture mechanism, Analysis and design of underground openings, Instrumentation in tunnels, Rock support and reinforcement, Foundations on rock, Rock blasting.

Texts/References:

1. Mukerjee, P.K., 1995. A text book of Geology, World Press.
2. Brady, B.H.G., Brown, E.T, 1993. Rock Mechanics for Underground Mining, Chapman & Hall.
3. Goodman, R.E., 1989. Introduction to Rock Mechanics, John Wiley & Sons.
4. Bieniawski, Z.T., 1989. Engineering Rock Mass Classification, John Wiley and Sons.
5. Wyllie, D.C., 1992. Foundations on Rock, 2nd Edition, E& FN Spon.

CE 654 Petrophysics (3-0-0-6)

Course Content:

The study of petroleum reservoirs; fundamentals of petrophysics; interrelation between petrophysical parameters; the borehole environment; hydrocarbon mobility; invasion profiles and invasion characteristics; acquisition and presentation of petrophyscial data (well logging); interpreting logging parameters (porosity, permeability, electrical resistivity, capillary pressure, relative permeability); study of rock properties (porosity, compressibility, gas permeability, liquid permeability); study of fluid properties; behavior of reservoir fluids, oil properties, gas properties, brine properties permeability correlations; permeability averaging and heterogeneity; study of fluid-rock interaction properties such as saturation and wettability; surface and interfacial tension.

Texts/References:

1. George, B.A., Charles, R.G., Basic Well Log Analysis, AAPC.
2. Darling, T., 2005. Well Logging and Formation Evaluation, Oxford, U.K., Elsevier, p5.
3. Sengel, E.W.B., 1981. Handbook on well logging, Oklahoma City, Oklahoma: Institute for Energy Development, p168.

CE 642 Subsurface Investigation and Instrumentation (3 0 0 6)

Course Content:

Problems and phases of foundation investigations; Geophysical, sounding, drilling and accessible explorations; Sample requirements, sampling methods and equipment; Handling, preservation and transportation of samples; Sample preparation, laboratory tests, analysis of results and interpretation, importance of in-situ testing; Performing various in situ tests; Precautions and interpretation; Field Instrumentation; Investigation below sea/river bed; offshore investigation; Site evaluation and reporting.

Texts/ References:

1. Bowles, J.E., 1985. Physical and Geotechnical Properties of Soil, McGraw-Hill Book Company.
2. Bowles, J.E., 1982. Foundation Analysis and Design , McGraw-Hill International edition.
3. Dunnicliff, J., Green, G.E., 1997. Geotechnical Instrumentation for Monitoring Field performance, John Wiley & Sons.
4. Gopal, R., Rao, A.S.R, 1991. Basic and Applied Soil Mechanics, Wiley Eastern Limited.
5. Lunne, T., Robertson, P.K., Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice, Blackie Academic & Professional.
6. Compendium of Indian Standards on Soil Engineering Parts 1 and II 1987-1988.

Elective IV

CE 655 Underground Exploration (3 0 0 6)

Course Content:

Theory and practice of rock fragmentation by drilling and blasting; introduction to explosives and initiation systems; design of surface and underground blasts; machine excavation systems for tunneling and stopping; environmental impacts, safety, and risk assessment; underground environment: dust suppression, ventilation, lighting, communication, fire protection; underground openings: dimensions, shape, structural response, sequence of excavation, rock conditions, stress distribution and failure prediction, caving and subsidence, failures in underground excavation; Structurally control instability, influence of geometry, in-situ stress, pillar design and failure, fracture propagation, stiffness, energy and stability, static and dynamic response of rock material during excavations; explosives and Charging Systems; Initiating Devices and Systems; Production Bench Blasting; Over break Control and Secondary Blasting; Damage Control; Safety and Accident Prevention; design and construction of large excavation: hydro-power station caverns, metro-railways, large diameter trenches, water carrying.

Texts/References:

1. Sinha, R.S., 1991. Underground Structures: Design and Construction, Elsevier, Amsterdam.
2. Mahtab, M.A., Grasso, P., 1992. Geomechanics Principal in the Design of Tunnels and Caverns in Rock, Elsevier, Amsterdam.
3. Esex, E.J., 1997. Geotechnical Line Reports for Underground Construction: Guidelines and Practices, American Society of Civil Engineers Pub.
4. Singh, J.G., 1999. Underground Mining, Monark Press, Bruj-Kalp Publisher, Varanasi.
5. Hudson, J.A., 1993. Comprehensive Rock Engineering (3-5), Pergamon Press, Oxford.

CE 557 Environmental Hydrology (2-0-2-6)

Course Content:

Basic concepts of environmental hydrology; water cycle, water balance and hydrological processes; environment and water; hydrology and climate, physical and biological interactions; water-related environmental problems; hydrological characteristics of India; drinking water, drinking water regulation and standards, water testing; forest hydrology, hydrological processes in forested area; urban hydrology, urbanization and hydrological processes, runoff process and flood; storm water storage and infiltration, reconstruction of urban water cycle; domestic, industrial, commercial, agriculture, and public water uses; water rights and development; water pollution and water quality policy, point and non-point source pollution and control, self-purification; sewage treatment; groundwater pollution, background and measurements of groundwater contamination, sources and fate of contaminants, organic solvents, phosphate and nitrate, remediation; Laboratory: Experiments to complement/supplement theoretical topics including physicochemical and bacteriological testing of surface and groundwater (majorcations-anions, total coliform and faecal coliform, Fluoride, Arsenic, Phosphorous, Nitrogen).

Texts/References:

1. Ward, A.D., Trimble, S.W., 2004. Environmental Hydrology; 2nd Edition, Lewis Publishers, CRC Press.
2. Watson and Burnett, 1995. Hydrology: An Environmental Approach, CRC Press.
3. Schwab, G.O., Delmar, D., Fangmeier, E., William, J., 1996. Soil and Water Management Systems, John Wiley & Sons.

CE 564 Stochastic Hydrology (3 0 0 6)

Course Content:

Review of fundamentals of probability and statistics, concepts of conditional probability, random variables and their transformations; concepts of moments and quantiles; commonly used probability distribution functions; principles of hypotheses testing; principles of Monte Carlo simulation and estimation theory; methods of maximum likelihood and least squares minimization; theory of random processes, estimation of linear static systems, random fields and stochastic-dynamic systems; Kalman filter and its applications in hydrologic real-time forecasting, stochastic characterizations and geostatistics; temporally and spatially variable subsurface flow analysis; theoretical approaches and applications of stochastic modeling to transport processes in heterogeneous porous media.

Texts/References:

1. Haan, C.T., 1977. Statistical Methods in Hydrology, Lowa State University Press.
2. Zhang, D., 2002. Stochastic Methods for Flow in Porous Media, Academic Press.
3. Bras, R.L., Rodriguez-Iturbe, I., 1994. Random Functions and Hydrology, Dover Publications.
4. Gelhar, L.W., 1993. Stochastic Subsurface Hydrology, Prentice Hall.

CE 565 Introduction to Multiphase Flow (3-0-0-6)

Course Content:

Introductory concepts of the physics and mathematics of multiphase flow; flow of immiscible fluids in porous media; pore level characterization; pore networks; invasion percolation in drainage and imbibitions; capillary pressures and relative permeability; upscaling; Buckley-Leverett theory of two- and three-phase immiscible displacements.

Texts/References:

1. Bear, J., 1972. Dynamics of Fluids in Porous Media, Dover Publications.
2. Adler, P.M., 1995. Multiphase flow in porous media, Springer.
3. Stauffer, D., Aharony, A., 1992. Introduction to Percolation Theory, Taylor and Francis, London.
4. Sahimi, M., 1994. Applications of Percolation Theory, Taylor and Francis, London.

Annexure-120/4(e) contd…….

CE 568 Environmental Management of Water Resources (3 0 0 6)

Course Content:

Environmental management- principles, problems and strategies; water resources management; Review of political, ecological and remedial actions; future strategies; multidisciplinary environmental strategies, the human, planning, decision-making and management dimensions; environmental impact assessment (EIA), definitions and concepts, rationale and historical development of EIA, sustainable development, Initial environmental examination, environmental impact statement, environmental appraisal, environmental impact factors and areas of consideration, measurement of environmental impact, organization, scope and methodologies of EIA, status of EIA in India; Environmental audit, definitions and concepts, environmental audit versus accounts audit, compliance audit, methodologies and regulations; introduction to ISO and ISO 14000; Life cycle assessment.

Texts/References:

1. John, G., Rau and David, C.W., 1980. Environmental Impact Analysis Handbook, McGraw-Hill.
2. Larry, W.C., 1997. Environmental Impact Assessment, 2nd Edition, McGraw-Hill.
3. Harrison, R.M., 1990. Pollution – Causes, Effects and Control, 2nd Edition, Whitstable Lithop Ltd.

CE 572 Pollution and Contaminant Flux in Water Environment (3-0-0-6)

Course Content:

Low temperature geochemical reactions in aqueous environments; chemical kinetics; thermodynamics, mixing and dilution, mineral stability, chemical composition of surface water, stable isotopes; contaminants and contaminants transporting near-surface environments; fluid – sediment interaction; fluid portioning; stability and mobility of groundwater contaminants; multi-phase systems; sampling considerations and overview of analytical techniques; flocculation, deposition and re-suspension of sediments; physicochemical processes at sediment water interface; fate and effects of sediment bound contaminants; partitioning of contaminants in water-sediment systems; bio assessment of sediment and water quality; effects of sediment mixing; parameterizing models for contaminated sediment transport; fluxes between trophic levels and through the water-sediment interface.

Texts/References:

1. Hemond, H.E., Fechner-Levy, E.J., 2000. Chemical Fate & Transport in the Environment, Academic Press.
2. Alena Mudroch, M.A., Paul, J.M., 2000. Manual of Physico-Chemical Analysis of Aquatic Sediments.
3. Bonin, J.J., Golterman, H.L., 1999. Fluxes between Trophic Levels and through the Water-Sediment Interface, Kluwer Academic publishers.
4. Eisma, D., 1993. Suspended Matter in the Aquatic Environments, Springer-Verlag, Berlin.

CE 552 Water Resources Systems Analysis, Planning & Management (3-0-0-6)

Course Content:

Basic concepts of systems, need for systems approach in water resources, system design techniques, problem formulation; optimization techniques, LP, NLP, dynamic programming, genetic algorithm, sensitivity analysis, capacity expansion; reservoir operation problems, simulation, case studies; planning, role of a planner, National water policies, public involvement, social impact, economic analysis.

Texts/References:

1. Loucks, D.P., Stedinger, P.J.R., Haith, D.A., 1987. Water Resources Systems Planning and Management, Prentice Hall, New Jersey.
2. Loucks, D.P., van Beek, M., Water Resource Systems Planning and Management: An Introduction to Methods, Models and Applications; UNESCO.
3. Hall, K.A., Draoup, J.A., 1985. Water Resources Systems Engineering, Tata McGraw, H., 1970. Neil, G.S.,Water Resources Planning, McGraw Hill.
4. National Water Policy, 1987. Ministry of Water Resources, Government of India.
5. Griffin, R.C., 2006. Water Resources Economics: The analysis of scarcity, policies and projects, MIT Press.

CE 567 Sediment Dynamics in Fluvial Systems (2-0-2-6)

Course Content:

Fluvial sediments; transportation and entrainment; physical &chemical characteristics; grain size distribution; chemical sedimentology; environmental chemistry of sediments; minerals in sediments, physical and chemical properties; texture, grain size, shape, sorting, surface features, packing, orientation, textural maturity, density, porosity, permeability, adsorption properties; Mechanical analysis of sediments: grade scale, frequency distribution and interpretation, laser particle distribution analysis, X-ray diffractometry, Atomic Absorption Spectrophotometry and scanning electron microscopy; shape analysis and their significance, graphical methods of representation of results;

Annexure-120/4(e) contd…….

particulate nutrient and contaminant flux; modeling approach to sediment flux and concentration; Laboratory: Experiments to complement/ supplement theoretical topics including sediment studies in XRD, SEM, LPA and AAS.

Texts/References:

1. Miller, R.W., Donahue, R.L., 2001. Soils in our Environment, Prentice Hall.
2. Griffiths, J.C., 2002. Scientific methods in Analysis of Sediments, McGraw Hill.
3. Dey, S., 2014. Fluvial Hydrodynamics, Hydrodynamic and Sediment Transport Phenomena Series, Springer.
4. Dominic, M., Toro, Di, 2001. Sediment Flux Modeling, Wiley International.
5. John, S.R., Robert, W.D., Werritty, A., 2006. Sediment Dynamics and Hydromorphology of Fluvial Systems, IAHS Press.

Elective V

CE 657 Engineering Seismology (3-0-0-6)

Course Content:

Earthquake Genesis: Type of earthquakes, Plate tectonic theory, Earthquake faults and mechanisms, Seismic gap theory; Seismic Wave Propagation: Type of waves, Attenuation of wave amplitude with distance, directivity pulse; Measurement of Earthquakes: Location and size of earthquake event, Seismograph and Accelerometer; Data Processing: Filtering and baseline correction, Spectrum-compatible ground motion; Strong Motion Characterization: Peak ground acceleration, Strong motion duration, Response spectrum, Fourier spectrum, Power spectral density function, Ground motion intensity measure; Seismic Hazard Assessment: Identification of seismic sources, Magnitude-Recurrence relationship, Factors affecting ground motion characteristics at a site, Attenuation laws, Seismic hazard evaluations in a given time interval, Seismic zonation maps; Local Site Conditions: Effect of site conditions on ground motion characteristics, Evaluation of site effects using statistical correlations and analytical techniques; Design Response Spectrum: PGA and response spectrum shape method, direct statistical correlations; Ground Motion Simulation: Fourier transform based simulation, Wavelet transform based simulation.

Texts/References:

1. Villaverde, R., 2009. Fundamental Concepts of Earthquake Engineering, CRC Press.
2. Stein, S., Wysession, M., 2014. An Introduction to Seismology, Earthquakes, and Earth Structures, Wiley India.
3. Sucuoglu, H., Akkar, S., 2014. Basic Earthquake Engineering: From Seismology to Analysis and Design, Springer.
4. Bozorgnia, Y., Bertero, V.V., 2004. Earthquke Engineering: From Engineering Seismology to Performance-Based Engineering, CRC Press.
5. Lee, W.H.K., Jennings, P., Kisslinger, C., Kanamori, H., 2002. International Handbook of Earthquake & Engineering Seismology, Part A, Vol; 81A (International Geophysics), Academic Press.

CE 658 Earth System Engineering (2-0-2-6)

Pre Requisite: Earth System Dynamics

Course Content:

Introduction to modeling; Develop model components and to evaluate the role of Earth system components such as energy balances, atmospheric and oceanic circulation; ocean-atmosphere; land-atmosphere coupling; hydrologic cycle; carbon cycle; Anthropocene; Developing model components from experiments; experimental design; standardization and calibration; Study on interactions of various processes by using observations from field data and remote sensing data; Modelling of geophysical and geochemical processes; operation of analytical instruments such as mass spectrometers; gas chromatographs; spectrophotometers; analysis and integration of geological; geochemical and geophysical data and modeling natural system related to hydrology; climate and tectonics.

Texts/ References:

1. Douglas, W., Burbank and Robert, S.A., 2011. Tectonic Geomorphology, 2nd Edition, Wiley-Blackwell.
2. Condie, K.C., 2013. Plate tectonics & crustal evolution, Pergamon Press.
3. Ehlers, C., Krafft, T., 2006. Earth System Science in the Anthropocene, Springer.
4. Levinson, A.A., 1974. Introduction to exploration geochemistry, Applied Publishing Ltd., Maywood, IL.
5. Bonham-Carter, G.F., 1994. Geographic Information System for Geoscientists Modelling with GIS, Pergamon Press, Oxford.

CE 606 Earthquake Engineering (3 0 0 6)

Pre-requisites: Structural Dynamics (CE504)

Course Content:

Earthquakes: Causes, Magnitude and Intensity, Ground Motions, Site effects, Sensors; Response spectrum: Construction, Characteristics, Design Response spectrum; Linear

Earthquake analysis: Idealization of structures, Response spectrum analysis, Torsionally coupled systems, Frequency domain analysis, Time domain analysis; Nonlinear Earthquake analysis: Force-deformation relationships, Equation of motion, Controlling parameters, Ductility demand, Allowable ductility; Earthquake resistance design: philosophy ductility based design, Detailing provisions, Codal Provisions, Concepts of passive controls; Geotechnical aspects: Dynamic properties of soil, dynamic earth pressures, Liquefaction and ground improvement techniques; Retrofitting and strengthening of Buildings and Bridges.

Annexure-120/4(e) contd…….

Texts/References:

1. Clough, R.W., Penzien, J., 1993. Dynamics of Structures, Second edition, McGraw Hill International edition.
2. Chopra, A.K., 1997. Dynamics of Structures-Theory and application to Earthquake Engineering, PHI.
3. Pauley, T., Priestly, M.S.N., 1992. Seismic design of reinforced concrete and masonry buildings, John Wiley and Sons.
4. Priestly, M.N.S., Seible, F., Calvi, G.M., 1996. Seismic design and retrofit of bridges, John Wiley and Sons.
5. Dowrick, D.J., 1987. Earthquake Resistant Design: for engineers and architects, John Wiley and Sons.

CE 659 Climate Change: Causes, Effects and Mitigation (3-0-0-6)

Course Content:

Introduction to Climate Change; History and Trends of Climate: Paleoclimatology and Climate archives; Climate Forcers: Internal, External and Human; Direct and Indirect Climate forcing: Green house gases, Clouds and Aerosols; Energy Balance; Overview of Climate models: Simplest models to Global Climate Models (GCMs); Biogeochemical cycles; Mitigation Strategies: Transportation, Energy supply, Buildings, Industry, Agriculture, Forestry and Other Land use; Economics, Environmental Laws and Politics of Climate Change; Special Topics: Case studies, Ocean currents, Ocean acidification; and Climate impacts on Precipitation and Evapotranspiration at the earth's surface.

Texts/References:

1. Seinfeld, J.H., Pandis, S.N., 2006. Atmospheric Chemistry and Physics: From Air Pollution to Climate Change, John Wiley & Sons.
2. Bloom, A.J., 2010. Global Climate Change: Convergence of Disciplines, Sinauer Associates.

3. Garatt, J.R., 1992. The atmospheric boundary layer, Cambridge University Press.
4. Watts, R.G., 2013. Engineering Response to Climate Change, CRC Press, Taylor and Francis Group.
5. Metz, B., 2010. Controlling Climate Change, Cambridge University Press.

CE 660 Landslide Engineering (3-0-0-6)

Course Content:

Introduction to landslide geohazard; socio-economic impacts of landslides; importance of landslide engineering: classification of landslides, landslide triggering factors; hillslope geomorphology and hydrology factors for rainfall induced landslides: earthquake induced landslides; landslide mechanisms and characteristics: influencing parameters; in-situ and laboratory investigations for landslide analyses; methods for assessment of slope stability; landslide susceptibility analysis; landslide hazard assessment; instrumentation for landslide monitoring and early warning systems; landslide mitigation measures.

Texts/ References:

1. Cheng, Y.M., Lau, C.K., 2008. Slope Stability Analysis and Stabilization New methods and Insights, Routledge Taylor & Francis Group.
2. Fenton, G.A., Griffiths, D.V., 2008. Risk Assessment in Geotechnical Engineering, John Wiley & Sons.
3. De Blasio, F.V., 2011. Introduction to the Physics of Landslides, Springer.
4. Lu, N., Godt, J.W., 2013, Hillslope Hydrology and Stability, Cambridge University Press.
5. Hunt, R.E., 2007. Geologic Hazards: A Field Guide for Geotechnical Engineers, CRC Press Taylor & Francis.

CE 666 Advanced Geological Engineering (3-0-0-6)

Course Content:

Geological Engineering, technological aspects in Geological Engineering (structural constructions, bridges and pavements, earthworks); characterization of the subsurface; surface mapping, drilling, and geophysics; surface and subsurface exploration methods; collection, evaluation and organization of data; exploratory drilling-methods, pattern and sequence, logging of drill hole data; planning of exploration drilling holes; geostatistical estimation of ore reserves; application of remote sensing and statistical analyses in mineral, groundwater and petroleum exploration; application of different geophysical and geochemical surveys and exploration strategies.

Texts/ References:

1. Vallejo, L.G.de., Ferrer, M., 2011. Geological Engineering, CRC Press.
2. Gribble, C., McLean, A., 2003. Geology for Civil Engineers, 2nd Edition, CRC Press.
3. Barry, H.G., Brown, B.E.T., 2013. Rock Mechanics, 626p, Springer.
4. Kuzvart, M., Bohmer, M., 1986. Prospecting and Exploration of Mineral Deposits, Elsevier, Amsterdam.
5. Marjoribanks, R.W., 1997. Geological Methods in Mineral Exploration and Mining, Chapman & Hall, London.

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