BS-MS. in Earth Sciences

Department of Earth Sciences
Indian Institute of Technology, Kanpur

CREDIT DISTRIBUTION
COURSE STRUCTURE
COURSE CONTENTS

A brochure

Table 1a: BS program in Earth Sciences					
I Semester			**II Semester**		
S: MTH 101A	3-1-0	11	**S:** MTH 102A	3-1-0	11
S: PHY 102A/PHY 103A	3-1-0	11	**S:** PHY 103A/PHY 102A (Lab)	3-1-0	11
S: PHY 101A/CHM 101 (Lab)	0-0-3	03	**S:** CHEM 101A/ PHY 101A (Lab)	0-0-3	03
TA: TA 101A	2-0-3	09	**ES:** ESC 101A	3-1-3	14
S: LIF 101A	2-0-0	06	**S:** CHM 102A	2-1-0	08
HSS: ENG 112A/HSS-1 (Level 1)	3-1-0	11	**MPSFL:** PE 102A	0-0-3	03
MPCFL: PE 101A	0-0-3	03			
	Total	**54**		**Total**	**50**
III Semester			**IV Semester**		
ES: ESC 201A: Electronics	3-1-3	14	**HSS:** HSS-2 (Level 1)	3-1-0	11
ES: SO-1: ESO213A: Fundamentals of Earth Sciences	3-0-0	09	**S:** SO-2: MSO201A: Prob. & Stat	3-1-0	11
ES: ESO-2: ESO201A: Thermodynamics	3-1-0	11	**DC-3:** Geomorphology and Earth Surface Processes **[**ES313A]	3-0-0	09
DC-1: Mineralogy and Crystallography [ES 311A]	3-0-2	11	**DC-4:** Fundamentals of Geophysics [ES314A]	3-0-0	09
TA: TA 201A (MSE)	1-0-3	06	**DC-5:** Igneous & Metamorphic Petrology [ES315A]	3-0-2	11
COM201A: COM200	0-0-5	05	**TA:** TA 202A (ME)	1-0-3	06
			DC-2 Field Geology I [ES 312A]	0-0-3	03
	Total	**56**		**Total**	**60**
V Semester			**VI Semester**		
ES: ESO-3: ESO204A: Fluid Mechanics and rate processes	3-1-0	11	**DC-10:** Geological Remote Sensing [ES415A]	2-0-2	8
DC-6: Structural Geology [ES411A]	2-0-3	09	**DC-11:** Hydrological system [ES419A]	2-0-0	06
DC-7: Sedimentary processes & stratigraphic principles [ES412A]	2-0-2	08	**DC-12:** Exploration Geophysics [ES416A]	2-0-2	08
OE-1: Open Elective	3-0-0	09	**HSS:** HSS-3 (Level 2)	3-0-0	09
DE-1: Economic Geology (Departmental Elective compulsory)[ES450A]	3-0-0	09	**OE-2**: Open Elective/ UGP-2 [ES392]	3-0-0	09
Communication Skills in Earth Sciences [ES400]	0-0-2	02	**DC-8:** Geochemistry **[ES413A]**	2-0-0	06
UGP-1: ES391A		09 (Extra credits)	**DC-9:** Field Geology II [ES414A]	0-0-6	06
	Total	**48**		**Total**	**52**
VII Semester			**VIII Semester**		
DC-13: Geological Evolution of Indian Plate [ES417A]	2-0-0	06	**DE-4:** Departmental Elective		08-11
DE- 2: Departmental Elective		08-11	**OE-5**: Open Elective	3-0-0	09
DE -3: Departmental Elective		08-11	**OE-6**: Open Elective	3-0-0	09
OE-3: Open Elective	3-0-0	09	**HSS:** HSS-5 (Level 2)	3-0-0	09
OE-4/ UGP-3 [ES393A]	3-0-0	09	**DE-5:** Departmental Elective		08-11
HSS: HSS-4 (Level 2)	3-0-0	09	**DC-14:** Field Geology III [ES418A]	0-0-4	04
			UGP-4: ES394A		09 (Extra credits)
Total		**49-55**	**Total**		**47-53**

Table 1b: BS-MS (PG Part – Category – A)(*from the same department*)					Template No. MS
	1st to 6th	**7th**	**8th**	**9th**	**10th**
C O U R S E S	COURSES AS DETAILED IN THE BS TEMPLATE	ES417A [06]	DE -4[08-11]	DEPG-1 [08-11]*	MS PROJECT ES599
		DE-2 [08-11]	DE -5[08-11]	DEPG -2 [08-11]*	
		DE-3 [08-11]	OE-5 [09]	DEPG-3 [08-11]*	
		OE-3[09]	OE-6 [09]	DEPG-4 [08-11]*	
		OE-4[09]	HSS-5 (Level 2)[09]	DEPG-5 [08-11]*	
		HSS-4 (Level 2)[09]	ES418A [04]	MS Project [09] ES599	
		49-55	47-53	49-64	36

DEPARTMENT COMPULSORY (DC) COURSE CONTENTS

ESO213A: Fundamentals of Earth Sciences Universe and its characteristics

Course Content: Solar System and Earth; The primitive Earth; Geological Time scale; Origin of life and major geological events; Numerical Dating. Rocks, minerals and soils; Plate Tectonics and Mountain building; Deformation and Geodynamics; Earthquakes, Volcanoes. Earth, Ocean, Land, Rivers, Atmosphere, Biosphere, Cryosphere and Climate; Energy budget; Carbon Cycle; Hydrological Cycle; Weathering and erosion. Coupled processes in Earth System; climate change, Geological resource (minerals, hydrocarbons and water); Sustainability and Anthropocene activities.

DC-1 Mineralogy and Crystallography (ES311)

Course Content: Chemical and physical properties and identification of common rock-forming (silicates, carbonates and oxides) minerals; crystallography, Unit cells, Crystal symmetry, classes and rotation, Systems, Plane and Bravais Lattices, Axial Ratios, Parameters, Miller Indices, Point Groups, Crystal Form, Zones, Crystal Habit, Stereographic Projection of Crystal Faces, Polymorphs and Pseudomorphs, Twinning; optical mineralogy, uniaxial, biaxial minerals; introductions to x-ray crystallography; crystal structures, chemistry, and origin and significance of the rock-forming minerals, Mineralogy of the Earth's crust, upper mantle, lower mantle and its Core.

Lab-work: Identification of minerals and rocks (hand specimens and optical microscopes). Independent projects that will include operation of scanning electron microscope, electron microprobe and x-ray facilities.

DC-2 Field Geology I (ES312)

Course Content: This course will provide an introduction to field work activities (3-4 days), how to use a Brunton Compass, reading of topographic maps, dip and strike measurements, and basics of lithological mapping.

DC-3 Geomorphology and Earth Surface processes (ES313)

Course Content: Fundamental concepts of geomorphic system; Earth's energy balance, global heat transfer, topography and bathymetry, liberation and flux of sediments, hydrological cycle and water budget. Guiding Principles of earth's surface processes**:** Conservation, transport rules, event size and frequency; rates of processes and ages of landscapes. Whole Earth morphology and large-scale topography; Exogenic and endogenic processes. The Surface water system: Drainage basins and river systems, river morphology and hydrology, hydraulic geometry and governing principles of open channel flow; river processes and landforms, river dynamics. The Groundwater system: Groundwater in hydrological cycle, groundwater flow and storage; chemistry of groundwater. The Atmospheric System: Atmospheric composition and mixing, atmospheric circulation, greenhouse effect. The Ocean and Coastal system: Coastal environment, waves, tides and currents; The relative movement of land and sea; coastal processes and landforms. Cryosphere – growth and decay of ice sheets,

controlling factors, Himalayan glaciers; Wind activity and geomorphic work, desertification and controlling factors. Global geomorphology and tectonics: Earth's physiography and landscape evolution;

Landforms and tectonics of plate margins and plate interiors; Tectonic uplifts and denudation – rates and controlling factors, Sea level change – evidence, mechanism and effects; coupled tectonic-surface process models.

DC-4 Fundamentals of Geophysics (ES314)

Course Content: Introduction to geophysics, Earth as a planet and member of the solar system, origin and evolution of the Earth, Internal structure of the Earth; Concept of plate tectonics, plate motions and triple junctions; Gravitation, gravity anomalies and its variations, geoid, isostasy, rheology; Geomagnetic field, its origin and variations, paleomagnetism, and geomagnetic reversals; Introduction to seismology, seismic waves - P, S and surface waves, seismograph, travel time curves and radial Earth structures, general properties of surface waves and normal modes, earthquake source theory, intensity and magnitude scales of earthquakes, PREM model, elastic rebound theory, global seismicity and tectonics, focal mechanisms, seismic anisotropy; Heat within the Earth, thermal structure of continental and oceanic lithospheres at subduction zones and spreading centers, mantle convection.

DC-5 Igneous & Metamorphic Petrology (ES315)

Course Content: This course will introduce igneous and metamorphic rocks and focus on the processes and principles involved in the generation of these rocks in a wide range of tectonic settings. Emphasis will be on developing skills necessary to understand and evaluate melt generation and crystallization, differentiation and chemical evolution of magma, and metamorphic processes etc. Topics to be discussed in detail are: Classification and Nomenclature of Igneous Rocks; Textures and Petrogenetic Interpretations; Thermodynamic evaluation of phase diagrams, Phase Diagrams for Binary and Ternary Systems; Chemical Petrology: Major and minor element, and isotopic compositional variations; graphical and mathematical models of magma evolution; Fractionation of trace elements during melting and crystallization; Generation and diversification of magmas; Types of metamorphism; Classification of metamorphic rocks; textures; Metamorphic mineral assemblages and chemographic (ACF, AKF, and AFM) diagrams; Metamorphic Facies; Metamorphic Reactions.

Laboratory exercises will focus on hand-specimens and thin sections (optical microscopy) characterization, igneous and metamorphic textures and petrogenesis interpretations.

DC-6 Structural Geology (ES411)

Course Content: Concepts of deformation and structures in Earth and planetary systems; Concepts of Continuum, Solid, Fluid, Tensor, Force, Stress and Strain; Basics of rheology and deformation mechanisms; Structures associated with extensional, compressional, sliding tectonics and erosion; Fold morphology, kinematics and mechanism; Normal, reverse, oblique and strike-slip faults; Fold and thrust belts; Measurement and presentation of 1-, 2- and 3D structural elements; Ductile shear zones; Poly-phase (superposed) deformation and overprinting relationships; Application of Structural Geology.

Lab-work: Measurement and presentation of structural elements; Stereographic projection and interpretation; Construction and interpretation of structural map, profile and balanced cross section; measurement of finite strain; studying structures under optical/electron microscope.

DC-7 Sedimentary Processes and Stratigraphic Principles (ES412)

Course Content: Basinal Sedimentary Systems : Sedimentary basins and production of sediments; Transport of sediment grains; depositional processes and forms; Post-depositional changes-lithification and diagenesis. Sediment grain, Bedforms and Sedimentary Structures: Mechanics of sediment transport and transport laws; Grain size parameters and distribution, grain shape and form; primary grain fabric; Bedforms & inorganic primary sedimentary structures. Sedimentary Facies analysis: Concept of sedimentary facies; facies relationships; controlling factors; facies association and models; Fluvial environments and facies; Lacustrine facies, Deltaic environments and facies models. Clay Sedimentology: Origin of clay minerals, clay minerals in fluvial, aeolian and lacustrine environments, paleoenvironmental interpretations. Techniques in clastic sedimentology: Grain size

determination; X-ray diffraction; Heavy mineral analysis; cathodoluminescence microscopy.

Earth's history in rock record, stratigraphic principles – lithostratigraphy, cyclostratigraphy, chronostratigraphy, event stratigraphy; depositional models, accommodation space seismic and sequence stratigraphy; Magnetostratigraphy, Application of paleomagnetism to the solution of problems in stratigraphic correlation and to the construction of a high-precision geological timescale, climatic and tectonic controls on stratigraphic development, case studies.

DC-8 Geochemistry (ES413)

Course Content: This course will focus on the chemical evolution of the Earth over geological time, and how chemical principles are used to study Earth Science.The following topics will be covered: internal structure of atoms, electronic structure, chemical bonding, and chemical properties of elements. Fundamnetals of Thermodynamics and its application in Earth Sciences. Aquatic geochemistry, primary silicates and chemical weathering, acids and bases, dissolution and precipitation reactions, mineral stability diagrams, Eh-pH diagrams, oxidation-reduction reactions. The origin and evolution of Earth and the solar system through high temeparture chemical processes, trace elements in igneous processes, modeling trace element partition during magma genesis. Radiogenic isotope geology and geochronology. Stable isotope geochemistry. Earth's hydrosphere and its interaction with surficial rocks, sediments, soils, biosphere and the atmosphere.

DC-9 Field Geology II (ES414)

Course Content: General overview of geological structures in the field; Concept of orientation and scale in the field; Identification, measurement and presentation of different structural elements (lineation, cleavage, foliation, schistocity etc.) and their mutual relationships. Morphology and elements of folds, fractures, faults, shear zones and macrostructures; Strain analysis from deformed objects; Techniques and ethics of geological samples collection; Large and small scale litho-structural mapping (on topo-sheet and white paper), cross-sections, and their interpretation for regional tectonic.

DC-10 Geological Remote Sensing and GIS (ES415)

Course Content: Spectra of earth's surface material; Basic principles of digital image processing – point and algebric operations, filtering and neighbourhood processing, RGB-HIS transformations, image fusion analysis, PCA, image classification and geometric operations; Modern platforms and techniques - INSAR techniques and its applications, UAV, and airborne sensors. Basic principles of Geographic Information System (GIS) and its application – decision support and uncertainty, multi-criteria evaluation. Remote sensing applications - River basin management, groundwater prospecting, lake and wetland studies, water quality mapping, vegetation Mapping and forestry applications; applications in glaciology and snow hydrology; snow cover mapping and prediction of snowmelt runoff; Coastal zone mapping and other related applications; Natural hazards – floods, landslides, earthquakes; Mineral resources evaluation.

DC-11 Hydrological system (ES419)

Course Content: Planet Earth's Hydrosphere: Its Contents and Diverse Processes that Fashion Climate and Ecology. Planet Earth's Fresh water System in the context of the Hydrological Cycle, Balanced at all Scales. Interconnected Sub-components, their Water Holding Capacity,time scales, Transport Characteristics, Quantification and Variabilities. A River Basin as a Balanced Open System, Detailed Structure of its Components and their Inter-dependent Variabilities. Insightful understanding provided by the Linear Systems Theory and its applications. Hydrological analysis: Watershed delineation, Analysis of Hydrological Systems at various scales from Watershed to River Basins. Water quality. Water resources mapping and management. Groundwater flow: Porosity and Permeability, Darcy's law, Laminar and Turbulent flow. Groundwater storage, Types of Aquifers, Aquifer properties affecting groundwater, Groundwater level fluctuations. Groundwater quality, Groundwater management including Rainwater harvesting and Artificial recharge.

DC-12 Exploration Geophysics (ES416)

Course Content: Introduction to exploration geophysics; Gravity and Magnetic methods: History of gravity-

magnetic explorations, elementary theories of gravity and magnetic methods, densities and magnetic susceptibilities of rocks and minerals, brief on gravimeters and magnetometers, data reductions, gravity-magnetic anomalies, interpretation and applications; Electrical and electromagnetic methods: Electrical properties of rocks and minerals, self potential and its origin, concepts of D.C. resistivity, various electrode configurations for sounding and profiling, interpretation of resistivity field data, induced polarization; Basic concept of EM induction, Maxwells equations, different EM methods, earth's natural electromagnetic field, magneto-tellurics, various applications of EM; Seismic methods: Basics of seismic theory, Geometry of seismic wave paths, seismic events, reflection and refraction methods, seismic data acquisition system, convolutional model, basic processing steps, basic velocity-depth modeling, interpretation of seismic data; Radiometric methods: Principles of radioactivity, radioactivity of rocks and minerals, measuring instruments and applications; Well logging: Borehole environment, concepts of porosity, permeability and saturation, principles of electrical, nuclear, density and sonic logging and well log interpretation.
Laboratory classes will provide hands-on experience with different geophysical instruments.

DC-13 Geological Evolution of Indian Plate (ES417)

Course Content: Overview of geologic and tectonic evolution of the Indian plate, major geologic and tectonic features of the Indian sub-continent, Geodynamics and major structural grains in the Indian sub-continent; Indian Mountain-buildings in geological time and space; Cratons (Dharwar, Singbhum, Bastar, Bundelkhand, Aravalli etc.) and their development in the Archean; Proterozoic basins (Chhatisgarh, Cuddapah, Marwar, Pranhita-Godavari and Vindhyan), Gondwana basin; Rifting, drifting, palaeomagnetic interpretation and the evolution of India's continental margins; The concept of Large Indian Provinces in global context; Rajmahal and Deccan volcanic provinces; Plateau uplift (Deccan, Tibet and Shillong); Phanerozoic stratigraphic records of peninsular India; The Himalaya mountains; northward flight of India and collisional orogenesis; Classification of the Himalayan ranges; Himalayan foreland development and Indus-Ganga-Brahmaputra plains.

DC-14 Field Geology III (ES418)

Course Content: The course is designed to provide practical experience in stratigraphy including field logging of stratigraphic sections, sedimentary facies identification and description, interpretation of sedimentary processes, depositional environments, post-depositional changes; soil profiles and soil-forming processes.The students will also be taught geophysical data acquisition using available geophysical equipments (e.g., gravimeter, magnetometer, VLF electromagnetic equipment, resistivitimeter equipment, GPR, Seismic, and Global positioning system).

LIST OF DEPARTMENT ELECTIVE (DE) COURSES

Table 2a: UG level DE courses

Sl no.	Code	Title	Course Type	Semester	Credits
3	ES450	Economic Geology	DE-1 (compulsory)	5th	3-0-0-0 [9]
4	ES450	Environmental Geology	DE		**3-0-0-0** [9]
5	ES452	Engineering Geology	DE		
6	ES453	Microstructures in Earth Sciences	DE		2-0-3-0 [9]
7	ES454	Geology of Fuels	DE		3-0-0-0 [9]
8	ES455	Analytical methods in Earth Sciences	DE		2-0-3-0 [9]

Table 2b: PG level DE courses

Sl no.	Code	Title	Credits
1	ES680	Quaternary geology and tectonic geomorphology	3-0-0-0[9]
2	ES681	Potential Field Theory in Applied Geophysics	3-0-0-0[9]
3	ES682	Seismic Exploration and Subsurface Imaging	3-0-0-0[9]
4	ES683	Planetary Geomorphology: Processes and Landforms	3-0-2-0[11]
5	ES684	Well logging	3-0-0-0[9]
6	ES685	Disaster Risk Mitigation and Management	3-0-0-0[9]
7	ES655	Solid Earth Geophysics	3-1-0-0[11]
8	ES654	Advance Structural Geology	3-0-0-0[9]
9	ES643	Aqueous Geochemistry	3-0-0-0[9]
10	ES658	Natural Hazards	3-0-0-0[9]
11	ES652	Igneous &Metamorphic Petrology	3-0-0-0[9]
12	ES657	Experimental Rock mechanics and rock physics	3-0-0-0[9]
13	ES659	Active Tectonics and Paleo seismology	3-0-0-0[9]
14	ES653	Applied sedimentology and Basin analysis	3-0-0-0[9]
15	ES645	River Science	3-0-0-0[9]
16	ES649	Isotope Geochemistry and Applications	3-0-0-0[9]
17	ES656	Geophysical Methods	3-0-0-0[9]
18	ES647	Geology and Geochemistry of Petrolium	3-0-0-0[9]

Among these DE courses some of them may be offered in a particular semester depending of the availability of the expertise in the department. However, UG level electives will be offered as per the template.

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(Last updated: August 2018)