GEOLOGY (GY) COURSES

GY 100 INTRODUCTION TO GEOLOGY AND GEOLOGICAL PROCESSES 3 UNITS

Objectives:
At the end of this course the student should be able:
To explain geology, its history and relation to other branches of natural sciences.
To describe basic concepts of geological sciences.
To describe the time scale in geology.
To explain Earth's internal and external processes, and major surface features resulting from these processes.
To explain Earth's natural geological hazards (geohazards) and how they occur.

Contents:
Historical development of geology as a Science; its subdivisions and relation to other Sciences. Origin of the planet Earth: its shape, size and internal structure. Geologic columns, time Scale and correlation. The rock cycle. External processes – weathering and erosion, the influence of climate and tectonic setting on weathering and erosion. Marine processes and deposits. Characterization of depositional environments (e.g. Aeolian, fluvial, shallow and deep marine). Interaction between the hydrosphere, the atmosphere and the biosphere. Internal processes – earthquakes and magmatic activity; types of metamorphism, introduction to faulting and folding of rocks. Dynamics of the lithosphere: plate tectonics and dynamics of the Earth.

Delivery: 45 lecture hours
Assessment: Coursework 40% and Final Examination 60%

Textbooks:
Duff, D. (1993) (Editor). *Principles of Physical Geology*. 791p., 4th Edition
Davidson J. Reed W. and Davis P.M. (1997) *Exploring Earth: An Introduction to Physical geology*. Prentice Hall.
Kennel. W, Hamlin and Howard J. D. (1998), *Exercises in Physical Geology*. Prentice Hall.
Press, F. and Siever, R. (1986). *The Earth*, W.H. Freeman, New York, 656p.
Lutgens F.K. Tarbuck E.J (1999) *Essentials of Geology*. Prentice Hall

GY 120 EARTH MATERIALS (MINERALS AND ROCKS) 3 UNITS
Prerequisite: GY100

Objectives:
By the end of this course, student should be able:
To identify common rock forming and ore minerals in hand specimen.
To identify the common rock types in hand specimen.

Contents:
Module 1 - Minerals
Define of mineralogy and its relation to other branches of earth Science, physical properties of minerals: crystal habit, cleavage, parting and fracture, hardness, specific gravity, colour streak and luster as identification criteria. Practical work for identifying common rock forming minerals, ores and gemstones.
Module 2 - Rocks

Nomenclatures of common igneous, sedimentary and metamorphic rocks. Petrographic properties of common igneous, sedimentary and metamorphic rocks in hand specimen. (colour, mineralogical composition, textures (absolute and relative grain sizes, grain shapes) and structures}. Common rocks to be covered will include Granite, Syenite, Granodiorite, Diorite, Gabbro, Ultramafic rocks, Obsidian, Rhyolite, Andesite, Basalt, Scoria lava, Pumice, tuff, Conglomerate, Sandstone, Siltstone, Mudstone, Limestone (coral, detrital and travertine), Shales, Slates, Phyllites, Schist, Gneiss, Amphibolite, Granulite, Marble, Quartzite, Mylonites/Cataclasites.

Delivery: 30 Hours of lectures and 30 Hours of Practicals
Assessment: Coursework 40% and Final Examination 60%

Textbooks:
H. Spencer, H. Shaffer P.R. and Perlman, R. (1991), *Rocks and Minerals*. Golden Books Pub.Co.
Klein, C. and Hurbult, C.S. Jr.,(1998), *Manual of Mineralogy*, 21st ed., J. Wiley, New York.
Walter, S (1993), *Handbook of Rocks and Minerals and Gemstones*. Houghton Mifflin 384p.
Spencer. H., Shaffer P.R. and Perlman, R. (1991), *Rocks and Minerals*. Golden Books Pub. Co.

GY 125 INTRODUCTION TO SURVEY AND MAPPING 3 UNITS

Course Objectives
By the end of this course, student should be able:
To read and interpret simple geological, topographical maps and cross sections.
To describe basic principles of surveying and make base maps.
To identify and describe sedimentary, metamorphic and igneous terrains
To explain causes and effects of coastal processes
To describe soil profiles and effects of mining along the coasts

Contents:
Introduction to surveying, theory and use of plane table, Use of GPS, Geological compass, Altimeter, tape measure, and theodolites, Introduction to geological maps, essential parts of a map, types of geological maps. Interpretation of geological structures; completion of outcrops, V-rule and three point problems.
Visits to sedimentary terrains of Lugoba, Msolwa and Wami, Jensen migmatite quarry. Beach processes coral reefs, beach erosion, Heavy mineral concentrates in beach sands. Visits to the mining areas – Sand and aggregate quarries, Salt pans, Kaolin deposits

Delivery 30 lecture hours, 20 Practical hours and 10 Field Excursions.
Assessment: Course work and Report Writing 50% and Final Examination 50%

Textbooks
Butler and bell, (1988), *Interpretation of Geological maps*, Longman Scientific.
Whyte W. S. and Paul R. E (1999), *Basic Surveying.* 4th Edition Butterworth- Heineman.

GY 200 OPTICAL MINERALOGY 3 UNITS

Course Objective
By the end of this course the student should be able:
To explain and apply the theoretical and practical knowledge and skills required in identifying non opaque minerals using a petrographic microscope.

Contents:
Properties of the light, principles of reflection, refraction and indices of refraction, dispersion absorption and colours, polarization. Polarizing microscope:- Parts of microscopes and their functions. Optical properties of minerals:-Their theoretical aspects, procedures for their determination in plane polarized light. Color, Pleochroism and Dichroism. Relief, Double relief, Becke line. Birefringence and double refraction (anisotropism), phase difference (the concept of retardation) and interference colours. Prosperties and use of accessory plates and the concept of compensation. Mineral extinction, direction of vibrations of slow and fast rays and signs of elongation. Undulose extinction, twin lamellae and twin extinction angles. Uniaxial and biaxial minerals, indicatrix figures, optic figures, and optic signs. Optical properties of most common rock forming minerals (quartz, feldspar, olivine, pyroxene, amphibole, mica, kyanite, sillimanite, epidote) Common accessory minerals (apatite, Scapolite, titanite, rutile, zircon).

Delivery: 30 lectures hours and 30 hours of Practicals
Assessment: Course work 40% and Final Examination 60%.

Textbooks:
William N., (1991), *Introduction to Optical Mineralogy*. Oxford University Press
Kerr, P. F., (1997), *Optical Mineralogy*. McGraw-Hill, New York. 492p.

GY 229 INTRODUCTION TO GEOCHEMISTRY 3 UNITS
Prerequisite: GY100, GY120

Objectives
By the end of this course the student should be able:
To explain the origin, distribution and abundance of chemical elements in the earth
To describe the factors governing the migration of the elements in igneous, metamorphic and sedimentary processes.

Contents:
Nucleosynthesis and abundance of chemical elements in the solar system; Composition and classification of meteorites; Chemical composition of major Earth compartments including the crust, atmosphere, hydrosphere and biosphere; Major and trace element compositions of magmas and major rock types; Introduction to geochemical thermodynamics; Aqueous solutions, solubility and activity products; Redox potential, Eh-pH diagrams; Geochemical migration of elements during metamorphism and chemical weathering; Geochemical cycle; Basic applications of geochemistry.

Delivery: 45 lectures hours
Assessment: Coursework 40% and Final Examination 60%

Textbooks:
Brownlow, A.H., (1996), *Geochemistry*. Prentice-Hall, London; 498p.
Rollinson H. (1993), *Using geochemical data, evaluation, presentation and interpretation.* J.Wiley
Gunter F. (1998), *Principles and Application of Geochemistry*. Prentice Hall; 600p.

GY 243 STRUCTURAL GEOLOGY 3 UNITS
Prerequisite: GY100, GY125

Objectives:
By the end of this course the student should be able:
To describe basic concepts of structural geology and basic theories of stress, strain and rheology.
To identify and report structural fabrics and construct their 3-D geometric patterns.
To solve simple structural problems.

Contents:
Definition of basic terms: stress, strain structures textures and attitudes. Stress in rocks and resulting strain.Stress analysis. Textures and their formations. Faults and Folds. Factors that control structural changes. Identification, description, and measurement of geological structures. Outcrop pattern and construction of fold-profiles. Stereographic projections: β and π diagrams, plotting of lineations.

Delivery: 30 Hours of lectures and 30 Hours of Practicals
Assessment: Coursework 40% and Final examination 60%

Textbooks:
Robert. D and Hatcher (1994), Structural *Geology*: Principles, concepts and problems. Prentice Hall.
Regan, D.M. (1985), *Structural Geology*: - An Introduction to Geometrical techniques. John Wiley. New York. 393p
Ramsay, J.G. (1983), *the Techniques of Modern Structural Geology*. Vol. 1: Strain Analysis. Academic Press. London., 307p
Mruma, A.H. (1997), *Introduction to Structural Geology*: Teaching Manual for undergraduate Students, University of Dar es Salaam. FoS/GY/MAN/003., 157p.

GY 245 REMOTE SENSING AND GIS APPLICATION 3 UNITS
Course Objectives:
By the end of this course the student should be able:
To use aerial photography and other remotely sensed data as inputs into a geographic information system.
To process, interpret, and analyse satellite imagery, aerial photography, and raster-based GIS data for geological mapping.
To use remote sensed image processing techniques and GIS in mineral and water exploration.
To use remote sensing and GIS data in mapping geohazards, route corridor mapping and resource mapping

Contents:
Remote sensing concepts and theory. Aerial photography. Aerial photo interpretation and photogrammetry. Earth orbiting satellites. Multisopetral and hyperspectral data. Image rectification, registration, and enhancement. Image classification, spectral signatures, and multi-image manipulation. Image classification accuracy assessments. Data merging and GIS integration. Remote sensing with radar. Differential GIS techniques and accuracy for ground control surveys and applications. Digital elevation models and terrain visualizations. Data transfer and integration for mapping. GIS and modeling applications. 3-D analyst extension and its application in geological mapping, evaluation of resources and route corridor assessment.

Delivery: 30 Hours of lectures and 30 hours of practicals
Assessment: Coursework 40% and Final examination 60%

Textbooks:
Lillesand, T.M. and Kiefer, R.W., (1994), Remote Sensing and Image Interpretation, Third Edition. John Wiley and Sons Ltd., New York, NY
Schott, J.R., (1997)., Remote Sensing: The Image Chain Approach, Oxford University Press, New York, NY
Bonham-Carter, (1997): Geographical Information Systems for GeoScientists-Modeling with GIS. Pergamon Press, 398p. ISBN 0 08 042420 1.
Software: ERDAS imagine Professional 8.3 or ENVI 3.0, or ILWIS

GY 250 CRYSTALLOGRAPHY AND MINERALOGY 3 UNITS
Prerequisite: GY100, GY120

Objectives:
By the end of this course the student should be able:
To explain and apply theoretical and practical knowledge and skills required to understand and describe the crystallographic, physical and chemical properties of common rock forming minerals with a view to understand their genesis.

Contents:
Crystallography: Definitions of basic terms in crystallography and recognition of symmetry elements, and their location in common shapes, designs, and objects.
Mirror planes, Rotation axes, Crystal forms, choice of co-ordinate axes and symmetry notation in crystal, indexing of planes and directions in lattice and on crystals, stereographic projection, contact goniometer measurements of interfacial angles and their stereographic projections, Development of the {111} or {112} form in several point group symmetries, Development of additional forms on the basis of Miller index and point symmetry, axial ratio calculations, symmetry and translation in one-and two dimensional patterns, space lattice, space groups, recognition of space group elements in crystal structures and introduction to x-ray identification of minerals.
Mineralogy: Crystal chemistry, Atomic and ionic radii, Bonding, Packing and co-ordination principle, Paulin's rules, Chemical composition, Systematic mineralogy: The non-silicates, Native elements, sulphides and sulfosalts, oxide, carbonates. Silicates: structural classification of the silicates, the nesosilicates: olivines, garnets and $A1_4Si0_5$ minerals, the sorosilicates: epidotes, the cyclosilicates: tourmaline, beryl and cordierite, Inosilicates: pyroxenes and amphiboles, phyllosilicates: serpentines, micas and clay minerals, tectosilicates: quartz, feldspars, feldspathoids and micas and clay minerals, tectosilicates: quartz, feldspars, feldspathoids and Scapolite.

Delivery: 30 lecture hours and Practicals 30 hours
Assessment: Coursework 40% and Final Examination 60%

Key Text Books
Klein, C. and Hurbult, C.S., Jr., (1998), *Manual of Mineralogy*. 21st ed., Wiley, New York,
Walter, S. (1993), *Handbook of Rocks and Minerals and Gemstones.* Houghton Mifflin 384p.

GY 252 FUNDAMENTALS OF ENGINEERING GEOLOGY 3 UNITS
Prerequisite: GY100, GY125

Course objectives:
By the end of this course the student should be able:

To apply geologic fundamentals to civil engineering.
To apply the theory and aspects of engineering geology, and its impacts on civil engineering planning, design, construction, and monitoring.
To explain expanded coverage of applied geophysical methods, investigation fundamentals, use of aggregate materials, site instrumentation, and remote sensing.

Contents:
Engineering geology – an overview: Geologic fundamentals. Mechanics fundamentals. Investigation fundamentals: The role of an engineering geologist. Elements of an investigation. Types of investigation. Engineering soil: Describing soil for engineering purposes. The engineering properties of soil. Uses of soil Science classification. Engineering properties of rocks: Intact rock. Rock masses. Engineering classification of rocks. Subsurface water: Occurrence and influence of subsurface water. Engineering significance of subsurface water. Instrumentation: Instrument components. Instrument types and applications. Planning an instrumentation program. Exploration: Maps. Remote sensing. Subsurface exploration. Construction uses of rocks: Aggregates. Riprap and other large rock materials. Engineering geology and earth processes: Safety, risk, and geologic forecasting. Earthquake-induced processes. Volcanic processes. Landslide processes. Subsidence. Expansive soils. Shoreline processes.

Delivery: 45 lecture hours
Assessment: Coursework 40% and Final Examination 60%

Textbooks:
Johnson R.B. and Degraff J.V. (1988), *Principles of Engineering Geology,* Amazon, 512p.
Bell F.G. (1993), *Engineering Geology*, Blackwell Science, 359p
Waltham T. (1994), *Foundations of Engineering Geology*, Blackie Academic & Professional, London. 96p.
Rahn P.H. (1996), *Engineering Geology*, Prentice Hall. 720p

GY 263 FUNDAMENTALS OF GEOPHYSICS 3 UNITS
Prerequisite: GY100

Objectives:
By the end of this course the student should be able:
To explain the Earth's internal structure and causes of earthquakes.
To explain the nature of earth's potential fields and their applications in geology
To comprehend basic knowledge of historical and present sources of heat within the earth.

Contents:
Physical divisions of the earth, Elastic waves, refraction seismology, characteristics and parameters of earthquakes. Earth's gravity field, measurement of gravity. Gravity anomalies and isostasy. Earth's magnetic field and its origin, magnetization of earth materials and palaeomagnestism. Heat flow: Sources of heat, earths heat flow and transfer. Application of geophysics to global tectonics and deep structural investigations.

Delivery: 45 hours of lectures
Assessment: Coursework 40% and Final Examination 60%

Textbooks:
William Lowrie (1997), Fundamentals of Geophysics. Cambridge University Press

Lillie Robert J. (1999), Whole Earth Geophysics: An Introductory Text Book for Geologists and Geophysicists. Prentice Hall. 360p.
Marobhe I.M. (1997), Introduction to Geophysics Teaching Manual. University of Dar es Salaam.

GY 260 SEDIMENTOLOGY AND SEDIMENTARY PETROLOGY 3 UNITS

Objectives

By the end of this course the student should be able:
To describe how sediments and sedimentary rocks are formed in different depositional environments and recognize the environments in ancient rocks.
To identify and classify sediments and sedimentary rocks in hand specimen and under an optical microscope.
To interpret the inherent signature of the geological processes.

Contents:

Sedimentary cycle, weathering, chemical, biological. Soil, laterites, kaolin, bauxite. Particle transport and sedimentation. Physical properties of particles, fluid dynamics of sediments in aqueous processes, Eeolian process, Glacial processes, Gravitation processes. Allochthonous sediments: classification of sandstone to rudites, mudstones to siltstones and Pyroclastics. Autochthonous sediments:
Classification of chemical sediments, biological sediments, biochemical sediments including carbonates and evaporates. Sedimentary structures: Primary inorganic sedimentary structures, Biogenic sedimentary structures, Paleo-sedimentary structures.
Environments and Facies: Environment of erosion, equilibrium and deposition. Environment of deposition, Sedimentary facies and sedimentary models. Mechanical and Chemical diagenesis, P-T changes with depth, Compaction, Mineralogical changes, Cementation and development in porosity and permeability Practicals:
Field studies of sedimentary structures, Petrographic analysis of hand specimen, thin sections and grain mounts (including sandstones and carbonates), Grain size analysis, Mineral separation techniques including heavy mineral separation and analysis.

Delivery: 30 lecture hoursand Practicals 30 hours
Assessment: Coursework 40% and Final Examination 60%

Textbooks:

Tucker M. (1991), *Sedimentary Petrology*: An introduction to the Origin of Sedimentary Rocks. Blackwell Sciences 260p.
Chamley H. (1990), *Sedimentology*, Springer Verlag 285p.
Selley, Richard (2000), *Applied Sedimentology*, Academic Press 457p.

GY 265 GEOLOGICAL MAPPING I 1 UNIT

Objectives:

By the end of this course the student should be able:
To make geological map in a sedimentary terrain

Content

A field camp of 4 weeks will be conducted to map sedimentary rocks in a selected area. Students will independently map an area (under staff supervision). Use of topographical maps as base maps. Outcrop documentation and plotting the locations on maps. Positioning in the field using different methods, section measuring, importance of field note books and log books and preparation of cross-sections.

Delivery: 4 weeks of fieldwork
Assessment: Logbook and field notebook =20%, Geological Map = 50% Report writing = 30%.

Textbooks:
Mc Clay (1987). *The mapping of Geological Structures*. Geological Society of London Handbook, Wiley.
Barnes J.W. (1999), *Basic Geological Mapping*. J Wiley, New York

GY 310 PRINCIPLES OF STRATIGRAPHY AND PALEONTOLOGY 3 UNITS

Prerequisite: GY260

Course objectives
By the end of this course the student should be able:
To describe the way rocks are arranged in Earth's crust, their spatial and temporal variation.
To explain major paleontological concepts.
To identify and describe major fossil groups and their application in stratigraphy.

Course Contents:
Developments in Stratigraphy: History on how the principles of stratigraphy evolved. Measuring time in geology: Chronology, chronometry, geochronology, Radioactive dating, palaeomagnetism, thermolumineScence. Lithostratigraphy: Nomenclature of lithostratigraphiy: Formations, members, groups etc.
Biostratigraphy: Nomenclature of Biostratigraphy: Bio zone, Acme zone, Chronostratigraphy: Nomenclature of chronostatic Scales: chronology and chronostratigraphy. Correlation: Time equivalency in rock bodies, Event stratigraphy.
Breaks and gaps in the geological record: Types and reasons for the breaks Reconstruction of paleogeography: Datailed stratigraphic columns, single profiles and cross-sections, Facies analysis: lateral and vertical successions of paleoenvironments.
General Palaeontological concepts: Definition and scope of the subject, preservation of fossil – biostratonomy, modes of fossilization, fossil diagenesis, palaeocology – ecosystems and ecological factors determining preservation of fossils; Theory of Evolution – fossils as evidence of evolution.

Delivery: 30 Lecture hours and 30 Hours of Practicals
Course Assessment: Coursework 40% and Final Examination 60%

Textbooks:
Doyle P. Bennet M.R.A.N Baxter (1994), *they Key to earth History*: An introduction to Stratigraphy. Cambridge University Press.
Hollis D. Herdnerg. (1976), *A Guide to Stratigraphic Classification*. Terminology and Procedure.
Black, R.M. (1989), *the Elements of Palaeontology*, 404p, Cambridge Univ. Press.

GY 311 METALLIC MINERAL DEPOSITS 3 UNITS
Objectives
By the end of this course the student should be able:
To classify different types of ores.

To explain, processes and mechanisms for mobilization, transportation and deposition of valuable metals in the earth to form ore deposits.
To systematic identify ore minerals using principles of reflected light microscope.

Contents:
Scarce and abundant metals; Ore and gangue minerals, ore deposit and ore body; Geological setting and classification of major ore deposits; Origin and composition of ore fluids, factors governing the concentration and deposition of metallic ores during magmatic, metamorphic and sedimentary processes; Genesis of principal ore deposits of Ferrous metals (e.g. Fe, Mn, Cr, Ti, Ni, Co, Mo) Non-ferrous and base metals (e.g. Al, Sn, W, Cu, Zn, Pb), Precious metals (e.g. Au, Ag, Pt-group), and Nuclear metals (e.g. U, Th), metallogenic Epochs and Provinces; plate tectonics and mineral deposits settings.

Delivery: 45 Lecture hours
Assessment: Coursework 40% and Final examination 60%

Textbooks:
Gulbert J.M. and Park C. Jr. (1986), *The Geology of Ore deposits*; W.H. Freeman and Company, New York, 984 p.
Skinner B.J. (1986), *Earth Resources* (3rd ed.), Prentice-Hall, New Jersy, 184p.
Evans A.M. (1992), *Ore geology and industrial minerals*. Blackwell Sciences
Sawkin F.J. (19840, *Metal Deposits in Relation to Plate Tectonics*, Springer-Verlag, New York, 325p.

GY 333 APPLIED GEOPHYSICS 3 UNITS
Objectives
By the end of this course the student should be able:
To describe the basic principles of geophysical techniques.
To explain value and limitations of geophysical data in geological investigation.
To interpret geophysical data

Contents:
Principles of geophysical methods: Gravity field instruments, observations and data reduction to Bouguer anomalies. Magnetic instruments, observations, reduction and interpretation. Electrical properties of rocks, resistivity, potential, induction and polarization. Seismic elastic properties of rocks, reflection and refraction methods. Electromagnetic induction laws, measurement of phase, amplitude and direction, interpretation of anomalies. Radioactivity measuring techniques and applications.

Delivery: 30 hours Practicals 30 hours
Assessment: Coursework 40% and Final Examination 60%

Textbooks:
Reynolds J.M. (1997) An Introduction to Applied and Environmental Geophysics. J. Wiley and Sons.
D.S. Parasnis (1996). Principles of Applied Geophysics, 5th Edition, Chapman and Hall, London.

GY 336 INTRODUCTION TO HYDROGEOLOGY 3 UNITS
Objectives:

By the end of this course the student should be able:
To describe basic concepts of hydrology and hydrogeology.
To interpret field hydrogeological data for groundwater supply.
To describe processes that brings about the quality of groundwater from hydrogeological data.

Contents:
Fundamentals of Hydrogeology*:* Hydraulics for hydrogeologists, terminology, storage, permeability, groundwater flow in aquifers, interfaces with hydrology, introduction to hydrochemistry radial flow to boreholes, simple aquifer tests, aquifer case studies. Introduction to concepts of hydrology. Groundwater exploration using hydrogeological and geophysical methods. Borehole geophysics.
Groundwater resources assessment and development: Aquifer test procedures and analysis, borehole construction and testing, interpretation of hydrometeorological data, unsaturated zone processes, recharge, base flow, aquifer boundaries, groundwater resources synthesis, and design of well fields.
Applications of geochemistry: Chemical constituents of groundwater, field sampling and laboratory analysis, geochemical processes in aquifers, solution thermodynamics, pH and chemical equilibria, gases in groundwater, elements of isotope hydrology in groundwater, water quality standards, operational aspects of hydrochemistry, chemical aspects of groundwater pollution.

Delivery: 45 lecture hours
Assessment: Coursework 40% and Final Examination 60%

Textbooks:
Freeze R.A. and J. Cherry (1979), *Groundwater*. Prentice Hall
Appelo A.C. & D. Postma (1993), *Geochemistry of Groundwater and Pollution*. Balkema Publishers.
Reynolds J.M. (1997), A*n Introduction to Applied and Environmental Geophysics*. J. Wiley and Sons.

GY 344 GEOMORPHOLOGY AND SOILS 3 UNITS
Objectives
By the end of this course the student should be able:
To describe basic principles of geomorphology
To classify types of soils as a technique to bedrock mapping.
To appreciate the relationships between geology, landscape development and soil cover.

Contents:
Study of geomorphology within the realm of Sciences; its definitions, approaches and terminology. Traditional models of processes, evolution and the resultant landscapes. Application of geomorphic theory to soil development and environmental problems: erosion processes, slope instability, coastal management.

Delivery: 45 lecture hours
Assessment: Coursework 40% and Final examination 60%

Textbooks:
Selby M.J. (1985), Earth's Changing Surface. Oxford University
Easterbrook, D.J. (1999). Surface Processes and Landforms 2nd Edition, Prentice Hall.
Rice R. J.(1988), Fundamentals of Geomorphology. Longmans

GY 351 FUNDAMENTALS OF SEISMOLOGY **2 UNITS**
Prerequisite: GY263

Objectives
By the end of this course the student should be able:
To describe basic knowledge on generation and propagation of seismic waves.
To explain basic knowledge on seismic sources.
To interpret seismograms, locate earthquakes and deduce mechanism.

Contents:
Elasticity and seismic waves: stress and strain, wave equations of P and S waves. Seismic wave propagation: Reflection and refraction of seismic waves, surface waves, Free Rayleigh waves, dispersion of surface waves. Instruments for detecting earthquakes. Seismogram interpretation, travel times in a layered and spherical earth, travel time curves. Locating earthquakes; single station; and multi-stations. Seismic source, causes of earthquakes, fault plane solutions, earthquake parameters.

Delivery: 30 lecture hours
Assessment: Coursework 40% and Final Examination 60%

Textbooks:
Stein S., (1991), *Introduction to seismology, earthquake and earth structure*. Department of Geological Sciences, Northwestern University.
Bullen K.E. and Bolt A. B. 1985, *Introduction to theory of Seismology*. Cambridge University Press.
Kulhanek O. 1990, *Anatomy of Seismograms*. Elsevier Science Publishers.

GY 352 MARINE GEOLOGY **2 UNITS**

Objectives
By the end of this course the student should be able:
To describe the structure and geomorphological evolution of the sea floor
To explain the marine geological processes
To explain nature and occurrences of marine mineral resources and the law of the sea.

Contents:
History of oceanography, Developments in methods and instrumentation used by marine geologists. Origin of ocean basins: The structure of the earth, Plate tectonics: sea floor spreading and continental drift. Geomorphological nomenclature and zonation of the ocean basin floor. Ocean circulation: Waves, ocean currents and tides Estuary and coastal processes, shre line and shoreline processes, Biological oceanographic processes, plankton and fish, the benthos. Resource potential of the sea water and sea floor, The law of the sea and the distribution of marine resources worldwide.

Delivery: 30 lecture hours
Assessment: Coursework 40% and Final Examination 60%

Textbooks:
Francis P. Shepard, (1973), Submarine Geology Harper and Row.

Seibold E. & W.H. Berger (1992) An introduction to Marine Geology Springer Verlag NY 288p.

GY 355 GEOLOGICAL MAPPING II **1 UNIT**

Objectives:

By the end of this course the student should able:
To make a geological map in a relatively complex terrain

Contents:

Geological mapping in the field using remote sensing data, and appropriate field techniques in a complex terrain. Recording outcrop information from various rock types. Map preparation and report writing under supervision.

Delivery: 4 weeks of field work
Assessment: Logbook snf Field notebook, 20% Geological Map 50% Report writing 30%.

GY 356 APPLIED GEOCHEMISTRY **2 UNITS**

Objectives

By the end of this course the student should be able:
To explain and apply principles of geochemistry and geochemical techniques in Earth Sciences, particularly in the search for mineral deposits.

Contents:

Basic principles of applied geochemistry; Geochemical mobility of elements in deep-seated and shallow environmental conditions; Dispersion halos and geochemical association of elements; Pathfinder and indicator elements; Background and threshold values and geochemical anomalies; Choices of sampling methods and media for geochemical surveys in mineral exploration; Principles of trace element analysis; Geochemical data handling and statistical interpretation; Applications of vapour geochemistry in forecasting of earthquakes and volcanic eruptions, and location of buried faults and geothermal areas; Other applications of geochemistry in geological and environmental studies.

Delivery: 30 lecture hours
Assessment: Coursework 40% and Final examination 60%

Textbooks:

Gunter, F., (1998), Principles and Application of Geochemistry, 2nd ed. Prentice Hall, 600p.
Rollinson H. (1993), Using geochemical data, evaluation, presentation and interpretation. J. Wiley.

GY 357 ISOTOPE GEOLOGY **3 UNITS**

Objectives

By the end of this course the student should be able:
To explain fundamentals of radiogenic and stable isotopes and describe their application in geochronology, petrogenesis, environmental and palaeoclimatic studies including the use of isotopes as tracers of earth processes.

Contents:

Stable and radiogenic isotopes, radioactive decay chains. Geochronology: the age equation, K-Ar, Ar-Ar, U-Pb, Rb-Sr, Nd-Sm, Lu-Hf chronometers, Fission track

dating, concept of closure temperature, thermochronology. Isotope geochemistry: isotope characteristics of the various earth reservoirs, use of isotopes to infer petrogenetic processes. Stable isotope geochemistry (C, O, S, H): applications to ore, environment, petrological and hydrological studies

Delivery: 45 lecture hours
Assessment: Coursework = 40 % Final Examination = 60 %

Textbooks:
Faure, G.H. (1995), *Principles of isotope geology*. John Wiley and Sons, New York.

GY 361 MAGMATIC PETROLOGY 3 UNITS
Objectives
By the end of this course the student should be able:
To classify igneous rocks.
To describe magmatic processes and their tectonic setting using mineral association, composition of major and trace elements, and simple phase diagrams.

Contents:
Origin, cooling and crystallization of magmas; magmatic fraction processes; intrusive rocks, shape and size of igneous rock fabric and texture, phanaretic and aphanitic and glass rocks; essential and accessory minerals in igneous rocks, classification of igneous rocks, colour index. Cumulate and non cumulate rocks. Mineralogical and textural characterisitics of common igneous rock types including peridotite, gabbro, and granite and their extrusive equivalents. Igneous rock associations and plate tectonics.
Generation and evolution of magmas; batch and fractional melting; magmatic series; tholeiitic, calc-alkaline, alkalic and peralkaline magmas; chemical variation diagrams. Harker and AFM plots; Fractionation indices. Construction of phase diagram; Lever rule; Phase diagrams for binary, ternary, and quaternary magmatic model systems. Eutectic and peritecti reactions; phase equilibria involving solid solution, congruent and incongruent melting; Liquidus projections and isothermal sections; Alkemade Theorem and Triangles. Partitioning of trace elements during equilibrium partial melting and magmatic crystallization; Partition coefficients (KD); Uses of trace elements in igneous petrogenesis.

Delivery:30 Lecture hours Practicals 30 hours
Assessment: Coursework 40% and Final Examination 60%

Textbooks:
Best M.G. (1995), Igneous and Metamorphic Petrology. Blackwell Sciences, 630p.
Philpotts A.R. (1990), Principles of Igneous and metamorphic Petrology. Prentice Hall.
Best M.G. (1995), Igneous and Metamorphic Petrology. Blackwell Sciences 630p.

GY 362 METAMORPHIC PETROLOGY 3 UNITS
Objectives
By the end of this course the student should be able:
To classify metamorphic rocks.
To describe physico-chemical processes, including the ability to infer metamorphic conditions from mineral assemblages, controlling metamorphism and the progressive metamorphic products of common protolith composition.

Content:
The concept of metamorphism. Types of metamorphism, controlling factors, Classification. Metamorphic reactions and metamorphic facies: the phase rule and variance of metamorphic reactions. Model metamorphic terrain: index minerals, isograds and metamorphic grade. Metamorphism of pelites, calcareous and igneous rocks.
Metamorphic petrogenesis; Metamorphism of common rock types: pelites, calcareous rocks and mafic igneous rocks; Metamorphic textures and structures; Relationship between regional metamorphism and tectonic processes. Metamorphic textures. Metamorphism as a way of looking at tectonics. Textures as a record of PT-deformation histories. The underlying principles: diffusion in solids and nucleation and growth of mineral grains. Textures of crystallization and recrystallization. Disequilibrium textures and the relative timing of metamorphism and deformation.
The relationships between regional metamorphism and tectonic processes. Metamorphism as a cycle in P-T space. Thermal budget of regional metamorphism. Model PTT paths and their use to inter-tectonic processes. P-T paths and facies series. Tectonic setting of metamorphism.

Delivery: 30 Lecture hours Practicals 30 Hours
Assessment: Coursework 40% and Final Examination 60%

Textbooks:
Best M.G. (1995), *Igneous and Metamorphic Petrology*. Blackwell Sciences, 630p.
Philpotts A.R. (1990), *Principles of Igneous and metamorphic Petrology*. Prentice Hall.

GY 363 INTEGRATED PROSPECTING METHODS 3 UNITS
Objectives
By the end of this course the student should be able:
To explain prospecting concepts, and their general application in locating earth resources.
To explain and apply prospecting using geological, geochemical and geophysical methods and to integrate geophysical, geochemical and geological data to reach a decision.

Contents:
Philosophy guiding exploration procedures: Criteria of prospecting for mineral deposits: structural, stratigraphical, magmatogenic, metamorphogenic, palaeogeographical and historical. Geological prospecting for ores in bedrock, placers, residual and concealed deposits. Definitions of basic terms in exploration geochemistry: Weathering, dispersion, anomaly, background values, geochemical province, Scales and sampling media, geochemical environments. Geochemical sampling methods: Lithogeochemical, solids drainage sediments, water, vegetation, volatile and airborne particulates. Data processing, and statistical interpretation. Physical properties of rocks and ore minerals as a criterion for prospecting, geophysical prospecting methods, airborne and ground geophysical methods, planning of geophysical data acquisition, processing and interpretation of geophysical data. Mining act of Tanzania. Case studies integrating geological, geochemical and geophysical data.

Delivery: 45 lecture hours
Assessment: Coursework 40% and Final Examination 60%

Textbooks:
Evans, A. M. et al., (1995), *Introduction to Mineral Exploration*. Blackwell Science Publishers, 396p.

Reynolds J.M. (1997), *An Introduction to Applied and Environmental Geophysics*. J. Wiley and Sons.
Rollinson H. (1993), *Using Geochemical data: Evaluation, presentation, interpretation*. J. Wiley & Sons.

GY 371 GEOTECTONICS 3 UNITS

Objectives:

By the end of this course the student should be able:
To understand and interpret major geotectonic processes and Units occurring on earth.

Contents:

General structure of the earth with emphasis on dynamics of continental and oceanic crusts. Concept and evidence of plate tectonics: continental drift, seafloor spreading, palaeomagnetism. Island arcs, transform faults, plate tectonics in place and time.
Evolution of the crust and upper mantle pof the earth. Large Scale deformational features and patterns of motion which occurs. Oceanic and continental rifts, mountains, volcanoes, earthquakes. Deformation of lithosphere under tension, compression, and vertical load.

Delivery: 45 ecture hours
Assessment: Coursework 40% and Final Examination 60%

Textbooks:

Kearey P. and Vine F.J. (1996). Global Tectonics, Blackwell Scientific Publications.
Keller E.A. & Nicholas Pinter (1995) Active tectonics: Earthquakes, Uplift, and LandScape. Prentice Hall.

GY 401 HISTORY OF THE EARTH 2 UNITS

Objective

By the end of this course the student should be able:
To explain procedures and methods of dating geological events.
Understand the variation of crustal forming processes, evolution of atmosphere, hydrosphere and biosphere throughout the entire geological history.

Contents:

Crustal evolution: Evolution of the earth, Crustal origin and evolution, Evolution and growth of early Archaean crust, Characteristics of Archaean Cratons, Growth and characteristics of Proterozoic mobile belts. The super-continents.
Evolution of Life: Evolution of atmosphere, hydrosphere and biosphere and their effect on lithofacies. Metazoan fauna during the late Precambrian, Biostratigraphy of the Phanerozoic with particular emphasis on Africa and Tanzania. Global mass extinctions; faunal and floral changes.

Delivery: 30 lectures hours
Assessment: Coursework 40% and Final Examination 60%

Textbooks:

Geofrey Davis. (2000) *Dynamic earth: Plates, Plumes and mintle convection.* Cambridge University Press.
Condie K.C. (1997). *Plate Tectonics and Crustal Evolution*. Butterworth Heinemann 288p.
Stanley S.M. (1986) *Earth and Life Through Time,* 689p W.H. Freeman and Company, New York.

Robert H. Dott, Jr and Donald R. Prothero (1994). *Evolution of the Earth*, 5th Edition. McGraw – Hill inc, 569 pp.

GY 409 INDUSTRIAL MINERALS AND ROCKS 2 UNITS

Objectives:

By the end of this course the student should be able:

To describe genesis, mode of occurrence, technical properties and specifications of industrial minerals.

To understand physical properties and uses of various types of rocks.

Contents:

Genesis, mode of occurrence, mineralogy, physical and chemical properties, specifications, industrial uses and economics of the following: ceramics and glass materials, building and structural materials, metallurgical and refractory materials, industrial and manufacturing materials, chemical materials, fillers and pigments, fertiliser materials, abrasives, gemstones, fossil fuels. Examples from Tanzania.

Delivery: 30 lectures hours

Assessment: Coursework 40% and Final Examination 60%

Textbooks:

Bateman, A.M. & Jensen, L.M., (1981), *Economic Mineral Deposits*. Revised III edition. John Wiley & Sons, New York, 592p

Evans, A.M., (1993). Ore Geology and Industrial Minerals, 3rd Ed., GeoScience Texts. 389p.

GY 404 MINERAL PROCESSING 2 UNITS

Objectives

By the end of this course the student should be able:

To describe principles of mineral processing and separation

Contents:

Recent theory and practice of crushing, grinding, Screening and classification. Gravity separation processes jigging, shaking tables, flowing film concentration, dense media separation, washability curves. Magnetic and electrostatic separation, ore sorting, solid liquid separation flocculation, selective flocculation, thickening, centrifuge sedimentation, filtration, thermal drying. Floatation fundamentals applied to separation processes, surface adsorption and floatation reagents, mineral bubble interactions, floatation equipment, floatation kinetics, floatation of sulphides, floatation of non-sulphides, coal floatation, agglomeration. Process water and waste management.

Delivery: 15 Lectures hours and 15 Practicals

Assessment: Coursework 40 % and Final Examination 60 %

Textbooks:

1. Wills, B.A. (1982). *Introduction to Mineral Processing*. Elsevier
2. Handbook of mineral processing –SME 1982

GY 405 INDEPENDENT PROJECT 3 UNITS

Objectives:

By the end of this course the student should be able:
To collect and analyze field and laboratory data and report the findings.

Contents:
The course will consist of assigned independent project that will include fieldwork, data presentation, seminar, writing and defending a dissertation before the Examiners. The student will be assigned a supervisor.

Delivery: 90 hours of Independent work
Assessment: Seminar 10%, Dissertation 90%

GY 406 PETROLEUM GEOLOGY 3 UNITS
Objectives
By the end of this course the student should be able:
To explain the origin of hydrocarbons, principles governing their migration and accumulation.
To recall and describe methods used for hydrocarbons exploration and production.

Contents:
Theories of the origin of petroleum, source rocks and maturation, reservoir rocks, traps, cap-rocks, migration and accumulation. Worldwide distribution of petroleum in time and space. Chemical and physical properties of petroleum and other reservoir fluids. Reservoir conditions. Drilling, recovery and production. Well log analysis, correlation, palynology, palaeontology and structural maps. Reserve estimation. Surface and subsurface methods of exploration. Petroleum potential of Tanzania. Legal aspects in the petroleum industry.

Delivery: 45 Lecture hours
Assessment: Coursework 40% and Final Examination 60 %

Textbooks:
1. Selley, R.C. (1993). Elements of Petroleum Geology, Academic Press.
2. Hobs, G.D. and Tiratso, E.M. (1981). Introduction to Petroleum Geology.

GY 407 BASIN ANALYSIS 2 UNITS
Objectives
By the end of this course the student should be able:
To use the acquired geological knowledge to explain the processes involved in the formation of a specific sedimentary basin and the associated mineral deposits

Contents:
Foundation of sedimentary basins, plate tectonic classification of sedimentary basins. Mechanisms of sedimentary basin formation, stress, strain, heat flow, Rock rheology, basins due to lithospheric stretching, basins due to flexure, basins associated with strike slip deformation. Sedimentary basins fill: stratigraphy and sedimentology of sedimentary basins. Evolution of sedimentary basins fill: subsidence history, thermal history, basin modeling. Application of petroleum play assessment. Application of the basin analysis model to a specific basin in Tanzania.

Delivery: 15 Lecture hours Practicals 30 hours
Assessment: Coursework = 40 % Final Examination = 60 %

Textbooks:
Allen, P.A. and Allen, J.R. (1992). Basin Analysis. Blackwell Scientific publications, 451pp.
Miall, A.D. (1990). Principles of sedimentary basin analysis. Springer Verlag, 668 pp.
Kleinspehn, K.L. and Paola, C. (1998). New perspectives in Basin Analysis. Springerverlag, 453 pp.

GY 410 ADVANCED HYDROGEOLOGY 2 UNITS
Prerequisite: GY336

Objectives
By the end of this course the student should be able:
To synthesize hydrological data in solving environmental problems.
To describe concepts of groundwater modelling and management of groundwater resources.
To interpret and establish natural processes influenced by groundwater.

Contents:
Flow net analysis, borehole construction, design, and well development, aquifer and well management strategies. Concepts of groundwater modeling: conceptual models, analogy models, numerical and mathematical models with examples. Multivariate statistical models as applied in hydrogeology. Goechemistry of groundwater and pollution protection.

Delivery: 30 Lecture hours
Assessment: Coursework 40 % and Final Examination 60 %

Textbooks:
1. Domencio, P.A. and Schwartz, F.W. (1990), *Physical and Chemical Hydrogeology*, 2nd edition. Wiley
2. Fetter, C.W. (1990), *Applied Hydrogeology*. Macmillan publishers.

GY 411 GEOLOGY AND MINERAL RESOURCES OF TANZANIA 3 UNITS
Objectives:
By the end of this course the student should be able:
To explain geology, evolution models, mineral resources and fossil fuels of Tanzania within the Gondwana framework.

Contents:
Precambrian: Geology, geochronology, mineral resources and evolution models for the Archaean terranes (i.e. Tanzania Craton), Proterozoic terranes (i.e. Ubendian – Usagaran foldbelt, Karagwe – Ankolean and Bukoban Supergroups, and Pan-African Mozambique belt). These aspects of Tanzanian geology are also eamined on a larger Scale, within the Gondwana framework.
Phanerozoic: Geology, stratigraphy and mineral resource evolution models of the following geologic Units: Karoo Basins of Tanzania (Upper Carboniferous – L. Jurassic). Coastal Marine Sedimentary Basin of Tanzania (M. Jurassic – Present). Cretaceous Continental Sedimentary basins. Cretaceous igneous rocks (kimberlites and carbonatites). Tertiary – Quaternary East African Rift Valley: rifting, sedimentation and volcanism. Erosional Land Surfaces and drainage patterns of Tanzania.

Delivery: 45 lecture hours

Assessment: Coursework 40% and Final Examination 60%

Textbooks:
McKinlay (1965), Coal Resources of Tanzania – Geological Survey of Tanganyika.
Quenell A.M. (1956), Summary of the Geology of Tanzania Introduction & Stratigraphy – Geological Survey of Tanganyika.
Harris (1960), Summary of the Geology of Tanzania – Economic Geology – Geological Survey of Tanganyika.
Kent P.E. (1971) Geology and Geophysics of Coastal Tanzania – Her Majesty.
Kaaya (1992). Depositional Environment of Late Permian Karoo beds in Ruhuhu and Mikumi. PhD Thesis University of Cologne.
Semkiwa. 1992 Depositional Environment and Coal Petrography Permian Coal Deposit in Karoo Basins of SW Tanzania, PhD Thesis, university of Cologne.

GY 412 ORE MICROSCOPY 2 UNITS
Prerequisite: GY311

Objectives
By the end of this course the student should be able:
To systematic identify ore minerals using the principles of reflected light microscopy.

Contents:
Hand specimen identification of common metallic and non-metallic economic minerals. Optical properties of opaque minerals and their uses in the identification of common native metals, metal oxides and sulphide. Interpretative studies of ore mineral textures in various ore mineral assemblages. Paragenetic positions of native metals, oxides and sulphide ores.

Delivery: 15 lecture hours 30 Hours of Practicals
Assessment: Coursework 40% and Final Examination 60%

Textbooks
Craig J.R. & Vaughan, D.J. (1994). Ore Microscopy and Ore Petrography. John Wiley & Sons, 406p
Ramdohr, P. (1976). The Ore Minerals and their Intergrowths. Pergamon, Oxford.

GY 413 MINING GEOLOGY 2 UNITS
Prerequisite: GY311, GY363,

Objective
By the end of this course students should be able:
To acquire techniques and procedures for carrying out reserve estimation, mine planning, development and closure.

Contents:
Introduction to drilling techniques, core logging, drilling equipment, reserves, resources and ores, ore value and concepts of ore body, cut off grade, grade control, relationship between grade and tonnage, reserve estimation. Geological mapping, (surface & underground), mine site engineering, mine mapping, ore body models and modelling.

Delivery: 30 lecture hours

Assessment: Coursework 40% and Final Examination 60%

Textbooks:
William C.P. (1987) Exploration and Mining Geology John Wiley & Sons.

GY 424 ROCK EXCAVATION AND SUPPORT 3 UNITS

Objectives
By the end of this course the student should be able:
To identify the requirements of excavation for different purposes.
To explain the geological problems associated with underground excavations, in rock mass conditions and appreciate the need for reinforcements.

Contents:
Drilling, blasting and mechanized excavation, rock reinforcement and support, foundations, surface excavations and support, underground excavations and support.

Delivery: 45 Lecture hours
Assessment: Coursework 40 % and Final Examination 60 %

Textbooks:
1. Attewel, (1995), *Tunnelling contracts and site investigations*. Routledge, 392 pp.
2. Hoek, E., Kaiser, P.K. and Bawden, (1995). Support *of underground excavations in hard rock*. 215 pp Balkema.
3. Franklin, J. and Dusseault, M.B. (1991). *Rock engineering applications*. McGraw
4. Abrahmson, L.W. Lee, T.S. and Boyce, G. M. (1995). *Slope stability and stabilization methods*. John Wiley and sons, Inc. 656 pp.

GY 431 DAM GEOLOGY 2 UNITS

Objectives
By the end of this course the student should be able:
To gather geological information that is required in feasibility studies, construction and post construction phases of dams.
To appreciate the significance of site conditions on the design and construction of dams and related infrastructure elements.

Contents:
Purpose and types of dams. Alternative dam site, reservoir sites and tunnel alignments. Site investigations. Dam construction materials. Design, construction and post-construction aspects. Case histories. Legal aspects.

Delivery: 15 Lecture hours 30 Practicals
Assessment: Coursework 40 % and Final Examination 60 %

Textbooks:
1. Kutzner, C. (1997). Earth and Rock Fill Dams. Principles of design and construction. Balkema, 346 pp.
2. Friedrick-Karl, E. (1985). Rock grouting with emphasis on Dam sites. Springer Verlag 428 pp.
3. Anon (1996). Safety evaluation of existing Dams: A manual for the safety evaluation of embarkment and concrete dams. Gordon press publishers.

GY 432 APPLIED ENGINEERING SEIMOLOGY **2 UNITS**
Prerequisite: GY351, GY256

Objectives
To appreciate the significance of geological and seismological input for the evaluation of seismicity and magnitude- frequency relation.
To map and give zone to a seismic hazards
To apply geological and geophysical knowledge in the earthquake-resistant design of engineering structures.

Content:
Earth structure and plate tectonics, strain accumulation, elastic rebound and faulting. Ground rapture, tsunamis. Energy release and seismic waves. Physical parameters of the earthquake source: hypocenter, magnitude, seismic moment and fault plane solution. Geological and seismological input for seismic evaluation and magnitude-frequency relations. Assessment of intensity and earthquake strong ground motions. Seismic hazard analysis and estimation of design ground motions. Seismic hazard mapping. Seismic zonation and response spectra in design codes.
Dynamic soil properties and pore pressure effects. Design parameter for real foundation materials. Evaluation of liquefaction potential. Effect of soil layers on ground motions. Response of foundations to earthquake motions. Seismic bearing capacity factors; seismic earth pressures on retaining walls.

Delivery: 15 hours of lectures 30 hours of practicals
Assessment: Coursework 40 % and Final Examination 60 %

Textbooks:
Kramer S. 1995, *Geotechnical Earthquake Engineering*. Practice Hall. 653p
Lindeburg 1996, *Seismic Design of Building Structures*: A Professional's Introduction to Earth Forces Design details.
Baradar M. 1997, *Seismic Principles Practice Exams for the California Special Civil Engineer Examination*. Professional Publications. 69p

GY 433 APPLIED ROCK MECHANICS **2 UNITS**
Objectives
By the end of this course the student should be able:
To explain stress-strain behaviour of different rock masses.
To describe mechanical and physical behaviour of the discontinuous rock masses and interaction of civil engineering structures.

Contents:
Characterization of rock materials and rock masses, physical and mechanical characterization of rock masses and deformation behavior, field and laboratory testing, methods to analyze mechanical behavior of rock masses, rock mass classification systems. DiScontinuities in rock masses, mechanical and physical behavior of diScontinuous rock masses, testing and monitoring, principles of tunnel and Dam design.

Delivery: 15 hours of lectures 30 hours of practicals
Assessment: Coursework 40 % and Final Examination 60 %

Textbooks:
Hudson J.A. & Harrison J.P., 1997. Engineering Rock Mechanics: An Introduction to principles. Pergamon Press. 456p
Hudson J.A 1995. Comprehensive Rock engineering : Principles, Practice &Projects

GY 446 ENVIRONMENTAL GEOLOGY **2 UNITS**
Prerequisite: GY228, GY263, GY336

Objectives:
By the end of this course the student should be able:
To explain natural geologic hazards and their effects to the environment.
To identify environmental impacts of mineral based industries and energy resources extraction.
To explain causes and effects of land degradation.

Content
Processes, effects, monitoring, mitigation of natural geological hazards: earthquakes, volcanoes, floods, drought, mass movements, toxic elements and compounds (As, F, Se, CO_2). Impacts of mining, waste disposal. Formation and processes of land degradation, conservation and rehabilitation. Human effects on the climate system and possible future trends.

Delivery: 30 lecture hours
Assessment: Coursework 40% and Final Examination 60%

Textbooks
Bell F.G. (1998), *Environmental Geology*: Principles and Practice. Blackwell Sciences.
Lowe, J.J. Walker, M. (1997), *Reconstructing Quaternary Environments*.
Manahan, S.E., (1993), *Fundamentals of Environmental Geochemistry*. Lewis, 844p.

GY 485 PRACTICAL TRAINING **2 UNITS**
Objectives
By the end of this course the student should be able:
To develop mapping skills acquired geological knowledge and ability to work independently.
To get acquainted with geological work undertaken by an exploration or mining company and research institutions

Contents:
The student will spend four weeks in the field doing independent mapping under supervision and other four weeks working with a company. The student will be assigned work and be jointly supervised by both the company's and department's staff members.

Delivery: 8 weeks working with a company
Assessment: Field notes 25% and Final Report 75%