B.Sc. I Year
Geology (GEO.101)

B.Sc. Year I
Subject: Fundamentals of Geology, Crystallography and Mineralogy, Structural Geology
Nature of course: Theory Course No.: GEO.101
Full marks: 100 Total period: 150
Pass marks: 35

Fundamentals of Geology

Total marks: 40 Total period: 62

Main Topics	Contents	Period	Marks
Introduction	The science of geology, scope, its various branches, method of study, application of geology in mineral resource, infrastructure developments, disaster mitigation.	4	12
Minerals	Definition, processes of formation, and classification of minerals	4	
Rocks	Classification of rock, rock cycle	4	
Earth's interior	Probing e Earth's interior, internal structure of the Earth, Earth's major internal boundaries, the crust, mantle and core, lithosphere and asthenosphere, pressure, temperature and seismic wave velocities inside the earth.	4	16
Earthquake	Earthquakes and faults; elastic rebound theory, seismic waves; seismograph, magnitude and intensity of earthquakes, world distribution of earthquakes, forecast and prediction of earthquakes	4	
Introduction to Plate tectonics	Continental margins, ocean basin floor, mid ocean ridge, Ocean trenches; earlier theories on geosynclines and continental drift; global plate systems, seafloor spreading and subduction zones; theories on coral reef development	8	
Isostasy	Gravity and continental crust.	2	16
Geological structures	Primary structures: Bedding, cross-laminations, ripple marks. Secondary structures: Faults, Folds, Foliation, Joints	4	
Weathering and mass wasting	Earth's external processes, weathering, soil formation, the soil profile, types and causes of mass wasting	6	
Geological work of running water	Runoff and discharge, geological importance of running water, process of stream erosion and deposition, floods	4	
Groundwater and its geological activities	Groundwater movement, water table, aquifers and aquicludes, wells, springs, geologic work of groundwater,	4	**16**
Glaciers and glaciations	Types of glaciers, glacier erosion and transportation, landforms associated with glaciers	4	
Geological work of sea and ocean	Geological work of sea and ocean and associated landforms	4	

Geological work of wind	Wind erosion, transportation, and deposition, eolian landforms	4	

Crystallography and Mineralogy

Total marks: 30 **Total period: 44**

Main Topics	Contents	Periods	Marks
Introduction to crystallography	Definition of crystals, Crystal symmentry elements, crystal face, Bravais law, law of constancy of interfacial angles, Crystallographic axes	2	16
Internal order in crystals	Symmetry operations, unit cell, lattice; Thirty-two point groups and their symmetry elements; Bravais lattices, screw and glide symmetries, concept of space group and international space notation	4	
Morphology of crystals and Crystal systems and classes	Axial ratios, parameter system of Weiss, Miller indices, forty-eight forms, combination of forms; Crystal systems: Classes and forms of Triclinic, monoclinic, orthorhombic, hexagonal, tetragonal and isometric systems	8	
Crystal growth and twining	Growth of crystals from solution and from a melt under controlled conditions, crystal growth in open fractures, solution cavities, or vesicles, Twining in crystals, different types of crystal twins, causes of twining in crystals, twin laws.	2	
Introduction to mineralogy and physical properties of minerals	Definition of mineral, scope of determinative mineralogy Scalar properties–colour, lustre, and streak, their definition and varieties with examples, specific gravity, determination of specific gravity of pure mineral grains by sink and float method, fluorescence and phosphorescence, magnetic properties–ferromagnetic, paramagnetic, and diamagnetic minerals.	6	16
Crystal chemistry of minerals	Vector properties–cleavage, parting, and fracture, their definitions, mineral examples, hardness–definition, Moh's scale of hardness, determination of hardness of minerals, crystallinity and forms of minerals–crystalline, cryptocrystalline, and amorphous, habit of minerals– elongated, tabular, flattened, and equant forms of crystalline and cryptocrystalline aggregates–type examples and use in identification. (a) Concept of crystal structure of minerals, Crystal structures and lattices of cubic system; dimorphism, polymorphism, and pseudomorphism, isomorphism and solid solutions.	6	
Chemical properties	Minerals as a chemical system; native elements,	4	

of minerals	sulphides, halides, oxides, silicates, titanates, phosphates, arsenates and vanadates, nitrates, borates and uranates, sulphates and chromates, tungstates and molybdates, oxalates and hydrocarbons. Rock-forming (silicate) minerals and their classification.		
	Introduction to economic minerals of Nepal	4	**12**
Introduction to optical mineralogy	Elements of optics, optics of isotropic medium– refractive medium, Snell's law; critical angle; anisotropic media, polarisation and interference of light, Polaroid, polarising microscope–construction and use, magnification and resolving power, construction and use of mica and gypsum plates and quartz wedge, pleochroism and birefringence, optical indicatrices – uniaxial and biaxial indicatrices, behaviour of light in uniaxial and biaxial crystals, optic sign, optical properties of minerals – form, cleavage, fracture, and parting, refractive index and relief, Bécké line and its use, twining, colour, and pleochroism, pleochroic forms of common minerals, properties under crossed polarisers – interference colour, twining, and extinction angle, anomalous interference colours, Michael Lévy chart and its use in determining thickness, path difference, birefringence, and order of interference colour, interference figures, optic sign of anisotropic medium, dispersion of optic axes in biaxial crystals.	4	
Mineral Genesis & Mineral classification	Formation of minerals by different endogenous and exogenous processes. Rock-forming (silicate) minerals and ore-forming (non-silicate) minerals. Silicate Classifications. Physical and optical character, mode of occurrence and important rock-forming minerals.	4	

Structural Geology

Total marks: 30 **Total period: 44**

Main Topics	**Contents**	**Periods**	**Marks**
Introduction	Introduction: Definition, scope of structural geology, concepts of detailed structural analysis: descriptive, kinematic, and dynamic analysis.	4	12
Geological map and cross-section	Geological map and cross-section, orientation of a line (trend and plunge) and a plane (dip and strike), use of a geological compass in measuring orientation of a line and a plane.	4	
Stereographic projection	Introduction to stereographic projection and its application in structural geology, plotting a line and a plane, finding the intersection of two planes, apparent and true dips.	4	

Stress and strain	Concepts of stress and strain, their definitions, stress in two dimensions, Mohr circle and its use.	4	
Unconformity	Bedding, conformity, and unconformity, types of unconformity, recognition of various unconformities in maps and cross-sections.	2	16
Intrusive contacts	Main features of intrusive contacts, sills and dykes, batholiths.	2	
Diapirs	Main features of diapirs and salt domes.	2	
Primary structures	Types of primary sedimentary and igneous structures and their application in structural geology, cross-cutting relationships and younging directions.	4	
Folds	Definition, classification of folds: anticline and syncline, antiform and synform, cylindrical and non-cylindrical folds, drag folds, criteria of recognition of folds in the field.	6	
Faults	Definition, classification of faults: strike slip, normal, and reverse faults, thrust faults, horst and graben, criteria of recognition of faults in the field.	6	16
Joints	Definition and classification of joints, study of joints in the field.	4	
Foliation and lineation	Cleavage, schistosity, and foliation, lineations and their classification, relationship of foliation and lineation with other structures in the field.	3	
Concepts of field geology	Topographic and geological map reading, use of geological compass, methods of plotting geological data on the maps and preparation of cross-sections.	3	

Text and Reference books

Fundamentals of Geology:

Strahler and Minzt, Physical Geology, Harper and Raw, New York (recent issue).

E. J. Tarbuck and F.K. Lutgens, 2005. Earth - An introduction to Physical Geology (8th Edition). Pearson Prentice Hall, New York

Donald Duff, 2004. Holme's Principles of Physical Geology, Routledge, UK.

J. E. Sanders, 1981. Principles of Physical Geology, John Wiley and Sons, New York.

Brian J. Skinner, Stephen C. Porter and Jeffrey Park, 2004, 5th Edition. Dynamic Earth: An introduction to Physical Geology. John Wiley and Sons. Inc.

Dahal, R.K., 2006. Geology for Technical Students. Bhrikuti Academic Publications.

Paudyal, K.R., 2005. Geology for Civil Engineers. Oxford International Publications.

Tamrakar, N.K. and Bajracharya, R., 2011. Handbook of Engineering Geology. Budha Academic Enterprises Pvt. Ltd., Kathmandu, 260p.

Tamrakar, N.K and Acharya, K.K., 2012. Environmental Earth Science. Dikshyanta Prakashan, Kirtipur, 398p.

Crystallography and Mineralogy

W. E. Ford, 2005, Dana's Textbook of Mineralogy (4th ed or latest edition). Wiley Eastern Limited.
L. G. Berry and Brian Mason, Mineralogy (2nd ed or latest) 2000, CBS Publishers and Distributors.
H. H. Read, Rutley's Elements of Mineralogy (26th ed). CBS Publishers and Distributors.
P. R. Joshi, H. R. Khan, D. R. Khadka and D. K. Napit, 2004. Mineral resources of Nepal, Published by Department of Mines and Geology, Lazimpat, Kathmandu.
L. P. Paudel, 2011. Study of Minerals and Rocks in Thin Sections. Geo-Science Innovations (P.) Ltd.
N. K. Tamrakar, 2011, Practical Mineralogy. Central Department of Geology, Tribhuvan University.
S. M. Rai, 2011. Study of Minerals and Rocks in Hand Specimens. Tara Rai, Kathmandu Nepal.

Structural Geology:

M. P. Billings, 1984, Structural Geology (3rd Ed.), Prentice-Hall of India Pvt. Ltd.
B. E. Hobbs, W.D. Means and P. E. Williams, 1976. An Outline of Structural Geology. John Wiley and Sons, New York.
N.W. Gokhale, 1996. Theory of Structural Geology. Satish Kumar Jain for CBS Publishers and Distributors, New Delhi, India.

B.Sc. I Year
Geology (GEO.102)

Subject: Fundamentals of Geology, Crystallography and Mineralogy, Structural Geology
Nature of course: Practical Course No.: GEO.102
Full marks: 50 Total period: 160
Pass marks: 20

Fundamentals of Geology

12 hrs

Lab 1: Study of geomorphic features using contour maps, and preparation of topographical profiles.

Lab 2: Study of structural block diagrams.

Lab 3: Study of some common igneous, sedimentary and metamorphic rocks

Crystallography

28 hrs

Lab 1: Study of space lattice models..
Lab 2: Study of crystal systems, crystallographic axes, interfacial angle, and measurement with a contact goniometer.
Lab 3: Study of forty-eight crystal forms.
Lab 4: Study of symmetry elements of thirty-two classes.
Lab 5: Construction of forms and stereographic projections of normal classes of the Triclinic and Monoclinic Systems.
Lab 6: Construction of forms and stereographic projections of normal classes of Orthorhombic And Hexagonal Systems.
Lab 7: Construction of forms and stereographic projections of normal classes of the Tetragonal and Isometric Systems.

Mineralogy

60 hrs

Lab 1: Study of physical properties of minerals. Crystal habit, hardness, cleavage, crystal form, streak and luster of quartz varieties, k-feldspars, plagioclase, micas, amphibole, pyroxene, Al-silicates, tourmaline, olivine, garnet.
Lab 2: Introduction of petrological microscope: Mechincal parts, optical parts, adjustment of microscope.
Lab 3: Observation of minerals in plane-polarized light: External morphology, cleavage, fracture, relief, color, pleochroism.
Lab 4: Observation of minerals in crossed-nicols: Isotropic or anisotropic, Extinction, interference color, birefringence.
Lab 5: Identification of essential rock-forming minerals in thin-section (Colourless minerals): Quartz, Feldspars, Pyroxene (Enstatite), Muscovite.
Lab 6: Identification of essential rock-forming minerals in thin-section (Colourless minerals): Calcite, Olivine, Kyanite, Sillimanite, Garnet.
Lab 7: Identification of essential rock-forming minerals in thin-section (Coloured minerals): Biotite, Chlorite, Pyroxnene (Hypersthene), Amphiboles.

Lab 8: Identification of essential rock-forming minerals in thin-section (Coloured minerals): Tourmaline, Staurolite, Epidote.

Structural Geology

60 hrs

Lab 1: Drawing of various geological structures and determination of their history of formation from block diagrams.

Lab 2: Study of geological maps: outcrop pattern of horizontal, inclined and vertical beds. Rule of V's. Inliers and outliers true and apparent dip of beds, true and apparent thickness, width of outcrop, horizontal and vertical thickness of beds. Relation between true thickness and width of outcrop.

Lab 3: Study of geological maps: determination of strike, true dip, and apparent dip of beds from geological maps measurement of thickness and width of outcrop from geological maps, completion of outcrops in geological maps.

Lab 4: Study of geological maps: Preparation of topographic profile, consequences of horizontal and vertical scale exaggeration in the profile. Preparation of geological cross-sections of horizontal, inclined, vertical, and folded beds. Geological map interpretation

Lab 5: Three-point problems and determination of attitude of beds.

Lab 6: Stereographic projection: principle of projection of a line and a plane, projection of inclined, horizontal, and vertical lines, projection of horizontal, inclined, and vertical planes.

Lab 7: Determination of intersection line of two planes; determination of apparent and true dips from given data, plotting trend, plunge, and pitch of a line.

B.Sc. II Year
Geology (GEO.201)

Subject: Petrology, Paleontology & Historical Geology, and Sedimentology
Nature of course: Theory Course No.:(GEO.201)
Full marks: 100 Total period: 150
Pass marks: 35

Petrology

Total marks: 40 Total period: 62

Main Topics	Contents	Period	Marks
(a) Igneous Petrology			
Introduction	Nature and scope of petrology, difference between petrology and petrography, General classification of rocks: igneous, sedimentary and metamorphic, general characteristics of igneous, sedimentary and metamorphic rocks.	2	24
Magma	Magma: Definition, composition, physico-chemical constitution, primary magma, magmatism in different tectonic environments.	2	
Evolution of magmas	Magma differentiation: fractional crystallization, other differentiation mechanisms, Magmatic mixing and assimilation.	2	
Forms and structures of igneous rocks	Intrusive igneous rocks: intrusive rocks and their relation to geological structures, intrusive forms, method of emplacement of intrusive rocks. Extrusive igneous rock: their structures and forms	4	
Textures and microstructures of igneous rocks	Crystallinity, granularity, crystal shapes and mutual relations among minerals, glasses.	2	
Crystallization of silicate melts	Unary and binary systems. Phase relations and textures, Ternary systems: Simple and complex, the effects of pressure on melting and crystallization of magma.	4	
Classification and description of igneous rocks	The IUGS classification system, chemical classification, characteristics of common igneous rocks: plutonic and volcanic, description of common igneous rocks.	4	
Formation of magma	Formation of magma: Rift zones, melting processes: partial melting, observations at the Mid-Oceanic Ridges.	2	
Igneous rocks in different tectonic settings	Igneous rocks at continental margins: Ophiolite suite, calcalkaline and tholeiite groups, plutonic rocks: batholiths related to subduction zones. Continental igneous rocks: gabbroic layered intrusions, anorthosite, alkali basalt and nephelinite, carbonatite, kimberlite and related rocks.	2	

(b) Metamorphic Petrology			
Metamorphism	Definition, types of metamorphism: regional, contact, burial, cataclastic, progressive, retrograde, inverse.	2	20
Metamorphic rocks	Definition, recognition in the field, distribution and nomenclature, structures and textures of metamorphic rocks. Shape of minerals, growth and mutual relation of minerals, petrographic descriptions of slate, phyllite, schist, gneiss, amphibolite, marble, quartzite, hornfels, serpentinite, granulite and eclogite. Control of metamorphism: pressure, temperature and composition in metamorphism.	4	
Metamorphic processes	Initiation of metamorphism, contact metamorphism, metamorphism of igneous rocks, submarine metamorphism, porphyroblasts, preferred orientation, metamorphic differentiation: compositional gradient, temperature gradient, differentiation by deformation, metamorphic reactions, the upper limit of metamorphism.	4	
Metamorphic zones	Index minerals, zones in contact metamorphism, isograds: Definition, dependence on temperature and pressures.	2	
Metamorphic facies and graphic representation	Definition of facies, evolution of concept of metamorphic facies. major metamorphic facies, phase rule, relationship of zones, grades and facies, graphic representation of ACF, AKF and AFM diagrams.	4	
Mineralogical phase rule	Invariant, bivariant reaction, invariant point and their significance (Triple point of Al_2SiO_5 and those in metamorphism of argillaceous rocks). Mineral variation related to initial rock composition: Carbonate rocks, mud rocks, mafic igneous rocks and tuffs, ultramafic rocks.	4	
(c) Sedimentary Petrology			
Introduction	Distribution of sedimentary rocks in time and space, formation of sediments, sediments and climate, tectonic setting of sediment accumulations.	2	18
Sedimentary textures	Size of sedimentary particles, Shape of sedimentary particles, concept of textural maturity.	4	

Sedimentary structures	Erosional, depositional and synsedimentary deformational structures and their significance.	4	
Classification of Sedimentary rocks	Classification based on texture and composition, genetic classification; Definitions, texture and structures, composition, and classification of sandstones, conglormerates, mudrocks, limestones and dolostones. Introduction to other sedimentary rocks: evaporites, bedded cherts, bedded phosphate rocks, bedded iron deposits.	6	
Diagenesis of sediments	Diagenetic stages and regimes, diagenetic processes: compaction, cementation, dissolution, replacement, recrystallization, authigenesis.	2	

Paleontology and Historical Geology

Total marks: 30 Total class hours: 44 hrs

Main Topics	**Contents**	**Periods**	**Marks**
Introduction	Aim, scope and objectives of paleontology, fossils and fossilization, index fossil, types of fossils, their mode of preservation, Importance of fossils, life through geological ages, organic evolution, evolution of life, Species: definition, concept and method of nomenclature, functional morphology	6	16
Invertebrate Fossils	Classification, geographical and geological distributions, morphology, Evolution and Evolutionary trend, Phylum Protozoa (*Foraminfera)* Coelenterate (*Anthozoa*), Arthropoda (*Trilobite*), Brayozoa, Brachiopod, Mollusca (*Bivalve*, *Gastropod*, *Cephalopoda*), Echinodermata (*Echinoidea)*, Hemichordata (*Graptoloidea*), Introduction of animal microfossils and applications (Radiolaria, diatom,Ostracoda/ Conodont), Introduction to trace fossils and their applications.	10	
Vertebrate Fossils and Paleobotany	Geological history through time of the following vertebrate groups: *Fishes, Amphibians, Reptiles, Aves and Mammals, Equidae, Proboscides and Hominidae*	4	14

	Plant fossils: Plant life through time (*Psilopsida, Lycopsida, Sphenopsida and Pteropsida*) Gondwana flora, Evolution of Angiosperms. Introduction to plant microfossils (pollen and spores, diatoms) and applications.		
Introduction to Historical Geology	Scope, aim, method of study, development of historical geology, problem of historical geology, the interrealtion of historical geology to other geological sciences, the geological time scale.	2	
Origin of the Earth and life	Origin of solar system, evolution of the Earth, development of the atmosphere, hydrosphere and biosphere, theory of origin of life, the first sign of life on the Earth, index fossils.	4	
Time on rock record	Introduction to relative and absolute time, Unit and measurement of geological time, geochronology, relative age determination, time stratigraphic units, introduction of lithostratigraphy, biostratigraphy, magnetostratigraphy and chronostratigraphy, method of correlation.	4	
The main tectonic unit of the Earth's crust and their evolution	Principal tectonic units of the present continents, the tectonic elements of oceans, tectonic evolution of the earth's crust.	2	14
Principles of paleoenvironment, Paleogeography, Paleotectonics	Introduction to marine and non-marine environments, Study of paleo-environments including the influence of organisms on sediments, methods of paleogeographic reconstruction, epirogenic movement of the crust, the analysis of the geological sections as a method of reconstructing crustal movements, methods of reconstruction of plaeotectonics	4	
The earliest (Precambrian) history of the earth's crust	The duration of the Precambrian era and the earliest known state of the crust, Development of Archean Cratons, the Precambrian shield rocks, Paleogeography during Precambrian, and Precambrian glaciations.	4	
Geological history of Phanerozoic eon	Plate position and motion, organic evolution, paleogeography and the crustal movements during the Cambrian, Ordovician, Silurian, Devonian, Carboniferous, Permian, Triassic, Jurassic, Cretaceous, Palaeogene and Neogene.	4	

Sedimentology

Total marks: 30 Total class hours: 44 hrs

Sedimentology			
Introduction	Definition of Sedimentology, History and development of sedimentology, Sedimentary rocks in space and time. Scope of sedimentology	2	44
Sedimentary processes	Physical processes: Fluid flow, Reynolds Number, Transport mechanisms: bedload and suspended load transport, transport in solution, Froude Number, Flow regimes and their significance, Flow regime and bed-forms, stream power and water depth, depth-velocity diagram. Subareal and subaqueous transport: Lahar, debris flows, turbidity currents and resulting bedforms	6	
	Chemical processes: Redox potential, pH, Eh-pH diagram, Geochemical Fence Diagram, Chemical processes of sedimentation: Dissolution, precipitation, formation of nodules and concretions	6	
	Biological processes: Metabolic process and hard parts generation, baffling and trapping, boring and chipping, pelletization, symbiotic relations among organisms, and microbial processes in generation of sediments.	4	
Depositional environments	Concept and classification of depositional environment	2	
	Continental Environments: Depositional settings, introduction to sedimentation processes of Fluvial, Lacustrine, Glacial and Eolian deposits.	8	
	Transitional Environments: Depositional setting, introduction to sedimentation processes of Deltaic, Estuarine, Barrier Beach Complex, and Tidal deposits.	8	
	Marine Environments: Depositional settings, introduction to sedimentation processes of Shallow Marine and Deep Marine deposits.	8	

Text and Reference books

Petrology:

E. G. Ehlers and H. Blatt, 1987. Petrology: Igneous, Sedimentary and Metamorphic. CBS Publishers & Distributors, New Delhi, India.

F. G. Turner and J. Verhoogen, 1987. Igneous and Metamorphic Petrology, CBS Publisher and Distributors, New Delhi, India.

W. W. Moorehouse, 1959. Study of rocks in Thin Sections, CBS Publishers and Distributors, India.

F. H. Hatch, A. K. Wells and M. K. Wells, 1984. Petrology of Igneous rocks, CBS Publishers and Distributors, New Delhi, India.

A. R. Philpotts, 2009, (2nd edition). Principles of Igneous and Metamorphic Petrology, Prentice-Hall of India Pvt. Ltd, New Delhi, India.

H. G. F. Winkler, 1987. Petrogenesis of Metamorphic Rocks, Narosa Publishing House, New Delhi-Madras-Bombay, India.

F. J. Pettijohn, 1984 (third edition). Sedimentary Rocks, CBS Publishers & Distributors, New Delhi, India.

Sam Boggs, Jr., 1992. Petrology of sedimentary rocks. Macmillan Publishing Company, New York.

J. D. Collinson and D. B. Thompson, 1989. Sedimentary structures, second edition. CBS Publishers & Distributors, Delhi

L. P. Paudel, 2011. Study of Minerals and Rocks in Thin Sections. GEOS, Kathmandu.

S. M. Rai, 2011. Study of Minerals and Rocks in Hand Specimens. Tara Rai, Kathmandu Nepal.

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Rabindra Kumar, 1992. Fundamentals of Historical Geology and stratigraphy of India. Wiley Eastern Ltd, New Delhi, India.

Henry Woods, 1998 (8th Edition). Invertebrate. CBS Publishers and Distributors, Delhi, India.

David M. Raup and Steven M. Stanley, 1985 (2nd edition). Principles of paleontology. CBS Publishers and Distributors, Delhi, India.

Shrock, R. Robert and Twenhofel, William, H., 1987 (second edition). Principle of Invertebrate Paleontology, CBS Publishers and Distributors, India.

H. L. Levin, 1999 (Sixth edition). The Earth through time. Saunder College Publishing.

E. N. K. Clarkson, 1979. Invertebrate Paleontology and Evolution, Harper and Row, New York.

Historical Geology

Roy A. Lemon, 1990. Principles of Stratigraphy, Publisher: Aerill Publishing Co.

Rabindra Kumar, 1992. Fundamentals of Historical Geology and stratigraphy of India. Wiley Eastern Ltd, New Delhi, India.

Don L. Eicher and A. Lee McAlester, 1980. History of the Earth, Prentice-Hall, Inc.New Jersey.

Sedimentology:

Don L. Eicher and A. Lee McAlester, 1980. History of the Earth, Prentice-Hall, Inc.New Jersey.

Richard A. Devis Jr., 1983 Depositional System (A genetic approach to sedimentary geology). Prentice Hall Inc. Englewod Cliffs New Jersey.

Donald R. Prothero and Fred Schwab, 1999. Sedimentary Geology - An introduction to sedimentary rocks and stratigraphy. W. H. Freeman and Company, New York.

H. E. Reineck. and I. B. Singh, 1973. Depositional Sedimentary Environments. Springer-Verlag, Berlin, New York.

S. M. Sengupta, 1994. Introduction to Sedimentology. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, India.

Gerard M. Friedman and John E. Sanders, 1978. Principal of Sedimentology, John Wiley and Sons, New York.

Roy Lindholm, 1999. A practical approach to sedimentology. CBS Publishers & Distributors, Delhi.

Maurice E. Tucker, 1996. Sedimentary rocks in the field. John Wiley & Sons, New York.

Publications of Journals of Nepal Geological Society.

M. R. Leeder, 1982. Sedimentology Process and Product, George Allen and Unmin, London.

N. K. Tamrakar, 2011. Practical Sedimentology. Bhrikuti Academic Publication. Kathmandu. Nepal

B.Sc. II Year

Geology (GEO.202)

B.Sc. Year II

Subject: Petrology, Paleontology and Historical Geology, and Sedimentology

Nature of course: Practical Course No.: GEO.202

Full marks: 50 Total period: 160

Pass marks: 20

Petrology **54 hrs**

Lab 1: Systematic megascopic study of igneous rocks.

Lab 2: Systematic megascopic study of sedimentary rocks including textures and structures

Lab 3: Systematic megascopic study of metamorphic rocks.

Lab 4: Microscopic studies of igneous rocks.

Lab 5: Microscopic studies of sedimentary rocks.

Lab 6: Microscopic studies of metamorphic rocks.

Paleontology

40 hrs

Lab 1: Study of Index fossils from Phylum Protozoa and Coelenterate

Lab 2: Study of Index fossils from Phylum Coelenterate

Lab 3: Study of Index fossils from Phylum Arthropoda

Lab 4: Study of Index fossils from Phylum Brachiopoda

Lab 5: Study of Index fossils from Phylum Polyzoa

Lab 6: Study of Index fossils from Phylum Mollusca (Class-Pelecypoda)

Lab 7: Study of Index fossils from Phylum Mollusca (Class Gastropoda)

Lab 8: Study of Index fossils from Phylum Mollusca (Class Cephalopoda).

Lab 9: Study of Index fossils from Phylum Echinodermata and Hemichordata.

Lab 10: Study of Vertebrate fossils.

Lab 11: Study of plant Index fossils through geologic time.

Historical Geology

12 hrs

Lab 1: Study of paleogeography, paleoecology and palaeoclimate of the Earth through geological time.

Lab 2: Study of paleotectonic (transgression and regression); Study of facies map their relation to sea level changes.

Lab 3: Preparation of columnar sections and their correlation (Litho and bio correlation).

Lab 4: Study of Geological Time Scale and Location of the Mountain orogengy, active volcanic area, convergent and divergent plate collision in the World Map

Sedimentology 54 hrs

Lab 14: Grain size analysis: Sieve analysis of sand and gravel, graphic presentation and interpretation of the data.

Lab 15: Grain size analysis: Pipette analysis of silt and clay, graphical presentation and interpretation of data.

Lab 16: Grain shape: Measurement of sphericity, form, roundness and surface features of detrital particles.

Lab 17: Description and interpretation of sedimentary structures: way up indicators, palaeocurrent indicators and deformation indicators.

Lab 18: Palaeocurrent analysis: Stereographic projection, correction of data for tectonic tilt, and construction of a rose diagram

Lab 19: Environmental models: Description and interpretation of facies and models of fluvial and lacustrine deposits.

Lab 20: Environmental models: Description and interpretation of facies and models of Deltaic and Tidal flat deposits.

B.Sc. III Year
Geology (GEO.301)

Subject: Geology of economic mineral deposits, Stratigraphy & Geology of Nepal, Geochemistry & Geophysics
Nature of course: Theory Course No.: GEO.301
Full marks: 100 Total period: 150
Pass marks: 35

Group A: Geology of Economic Mineral Deposits

Total marks: 25 Total period:38

Main Topics	Contents	Period
Introduction	Mineral deposits and ore fields, ore genesis, ore texture and structures, mineral association, stages of mineralization, ore reserves, ore and gangue minerals, workable limits, Mineral resources: economic, sub-economic ore deposits/ prospects and occurrences. Grade, Tenor & Tonnage ore.	4
Formation of Mineral Deposits	Magmatic concentration, sedimentation, metamorphism, contact metasomatism, hydrothermal deposits, oxidation and supergene enrichment, sublimation and evaporation, residual and mechanical concentration (heavy mineral concentrate/ placer deposits), Bactereogenic deposit. Submarine Exhalation and volcanogenic deposit.	12
Distribution of mineral deposits	Mineral paragenesis and zoning, metallogenic epochs and provinces; geological controls on location of mineral deposits.	4
Metallic deposits	Classification: Precious metals, Ferrous metals; Non-ferrous metals, Light metals, Radioactive metals, and Rare metals, Rare Earth Elements. Chemical composition, important physical properties, mode of occurrence, utilization and world distribution (including Nepal): ores of lead, zinc, copper, Nickel, Cobalt, Aluminum, iron and gold, rare earth elements.	8
Non-metallic Deposits:	Classification: Fossil fuels, gemstones, abrasives, construction materials and decorative stones, industrial minerals. Chemical composition, important physical properties, mode of occurrence, utilization and world distribution (including Nepal): magnesite, limestone, coal, petroleum and some selected gem stones (quartz, garnet, ruby, tourmaline, beryl).	10

Group B: Stratigraphy and Geology of Nepal

Total marks: 50 Total period: 75

Main Topics	Contents	Period
Stratigraphy		
Fundamentals of Stratigraphy	Aim, scope, origin and development of basic principles and establishment of stratigraphic units.	4
Stratigraphic classification and Nomenclature	Stratigraphic classification, Naming of stratigraphic units, lithostratigraphic, biostratigraphic, chronostratigraphic and magnetostratigraphic units. Formal and informal units.	10
Stratigraphic correlation	Criteria of correlation, lithostratigraphic, biostratigraphic, chronostratigraphic, magnetostratigraphic units/succession.	10
Establishment of stratigraphic units	International guide and code on stratigraphic classification and nomenclature, Preparation of columnar sections, classifications, naming, dating and publication. Revision of stratigraphic units. Homonyms, synonyms. Major standard stratigraphic units and index fossils. Introduction to sequence stratigraphy.	13
Geology of Nepal		
Broader framework and sub-divisions of the Himalaya	Relation of the Himalaya with other mountain chains of the region, Geomorphic sub-divisions, tectonic sub-divisions. Introduction to the geology of adjoining regions.	6
Stratigraphy of the Nepal Himalaya	Established stratigraphy of the Sub-Himalaya, Lesser Himalaya, Higher Himalaya and Tethys Himalaya. Quaternary successions of the Kathmandu basin, Pokhara basin and Thakkhola basin. Indo-Gangetic Plain.	10
Evolutionary history of Nepal Himalaya	Precambrian, Paleozoic, Mesozoic and Cenozoic evolutionary history of the Himalaya (sedimentation, tectonics, metamorphism, magmatism)	14
Mineral Resources of Nepal	Geological controls on metallic and non-metallic mineral deposits, precious and semi-precious stones, fossil fuels, coals and hot springs of Nepal. Current status of mineral resources development of Nepal.	8

Group C: Geochemistry and Geophysics

Total marks: 25 Total period: 37

Main Topics	Contents	Period
Introduction to geochemistry	Definition, principles and scope of geochemistry.	2
The structure and composition of the Earth	Internal and/or zonal structure of the Earth, composition of the crust, composition of the Earth as a whole, pre-geological history of the Earth.	6

Geochemical classification and differentiation	Geochemical classification of the elements, primary and secondary differentiation of the elements,	6
Geochemical cycle	Earth as a physicochemical system, the crust as a separate system, the geochemical cycle. Energy changes in the geochemical cycle.	4
Introduction to geophysics	Introduction to geophysics, application, limitations and ambiguity.	2
Gravity method	Introduction to gravity method, Gravitational field (force and potential), gravity instuments (gravimeters and variometers), gravity anomalies (Bouguer Anomaly), application and limitation.	4
Electrical method	Electrical properties of rocks, electrical field caused by a point charge, electrical survey methods, application and limitations.	7
Seismic method	Sources of seismic energy. Principles, applications and limitations of Seismic refraction and reflection methods.	6

Geology of Economic Mineral Deposits

1. Mead L. Jansen and Alan M. Bateman, 1981 (Third edition).*Economic Mineral Deposits*, John Wiley and Sons, New York.
2. Evans, A. M. (1993): *Ore Geology and Industrial Minerals*,Blackwell Scientific Publications,Sinha, R. K. and Sharma N. L. (197.): *Mineral Economics*, Oxford and IBH Publishing Company, India
3. Smirnov, V. I. (1989): *Geology of Mineral Deposits,* Namechand and Brothers, 520 p.
4. Craig and Vaughan (1981): *Ore Microscopy and Ore Petrography*, John Wiley &Sons Inc., New York.

Stratigraphy

1. Roy A. Lemon, 1990.*Principles of Stratigraphy,* Publisher: Aerill Publishing Co.
2. Donald R. Prothero and Fred Schwab, 1999.*Sedimentary Geology-An introduction to sedimentary rocks and stratigraphy*. W. H. Freeman and Company, New York.

Geology of Nepal

1. Gansser, A. (1964). *Geology of Himalayas*, John Wiley and Sons Inc.
2. Shakleton, R. M.., Dewey, J. F. and Windley, B. F. (eds.), 1988. *Tectonic evolution and Himalaya and Tibet*, Cambridge University Press.
3. Valdiya, K. S., 1980. *Geology of the Kumaon Lesser Himalaya*,Wadia Institute of Himalayan Geology.
4. Valdiya, K. S., 1984. *Aspects of Tectonic focus on South Central Asia*, Tata McGrawHill.
5. Valdiya, K. S., 1998. *Dynamic Himalaya,* Universities Press, New Delhi.
6. Sah R.B. (2013). Stratigraphy of Nepal.
7. Paudel, L. P., 2011. *Mineral Resources of Nepal: An analytical study* (in Nepali).
8. Research articles in various issues of the Journal of Nepal Geological Society, Bulletin of the Department of Geology, TU, journals of Stratigraphic Association of Nepal (SAN) and international earth science journals.

Geochemistry

1. Masson, B. and Moore, C. B. 1991. *Principles of Geochemistry*, 4th Edition, Wiley Eastern Limited, India, 350 p.
2. Hawks and Webbs, 2008. *Geochemistry in Mineral Exploration*. Harper & Row, 415p.

Geophysics

1. Kearey, P. and Brooks, M. 1988. *An Introduction to Geophysical Exploration*, ELBS 1st edition, Blackwell Scientific publication, 296 p.
2. Milton B. Dorbin, 1988. Introduction to Geophysical Prospecting (International Student edition), McGraw-Hill International Book Company.

B.Sc. III Year
Geology (GEO.302a)

Subject: Geology of economic mineral deposits, Stratigraphy and Geology of Nepal, Geophysics & Geochemistry
Nature of course: Practical and Field Work Course No.: GEO.302a
Full marks: 30 Total period: 160
Pass marks: 12

Practical:

Geology of Economic Mineral Deposits

- Preparation of mineral maps of Nepal**.**
- Study of ores and industrial minerals in hand specimen.
- Study of polish sections of important ores in reflected light.

Stratigraphy

- Study of standard stratigraphic scale.
- Study of index fossils of each major standard stratigraphic units (systems).
- Study of standard magneto-stratigraphic scale.

Geology of Nepal

- Study of geological map of Nepal.
- Study of Precambrian, Palaeozoic, Mesozoic and Cainozoic stratigraphy of Nepal Himalaya.

Geochemistry and Geophysics

- Statistical treatment of geochemical data (mean, mode, variance, kurtosis, standard deviation).
- Resistivity methods (profiling and sounding) and interpretation.
- Seismic refraction method and interpretation.

B.Sc. III Year
Geology (GEO.302b)

Subject: Field Work
Nature of course: Field Work Course No.: GEO.302b
Full marks: 20 Total period: 160
Pass marks: 8

Field Work (Duration-17 days):
Providing techniques of locating observation points in a topographical map, measuring attitude of beds and plotting them in a topographical map, observing different rock types, primary and sedimentary structures found in the field area, preparing route map taking geological traverses. Preparing geological map, geological cross-section, and stratigraphical column of the investigated area.

Field work site: The geology department will select appropriate field work site to meet the above objectives.

Note: Each student shall compulsorily attend the field work and submit a report.

B.Sc. IV Year
Geology (GEO.401)

Subject: Exploration Geology and Mining Geology

Nature of course: Theory | Course No.: Geo.401
Full marks: 100 | Total class period: 150
Pass marks: 35

A. Exploration Geology

Total period: 75 | Total Marks: 50

Main Topics	Contents	Period
Introduction	Importance of mineral resources. Stages of mineral resource development: prospecting, exploration, mining, processing and marketing. Factors affecting the distribution and localization of mineral deposits. Prospecting criteria, guides, wall rock alteration, primary and secondary haloes, metallogeny, metallogenic epochs, provinces, prognostic maps.	**20**
Exploration	Reconnaissance, prospecting, pre-feasibility, feasibility, engineering and mine exploration. Exploration methods: geological reconnaissance traverse, panning, remote sensing-landsat system, photogeology. Application of geophysical methods for mineral exploration: magnetic survey, gravity survey, radiometric survey, resistivity, seismic methods, Ground Penetration Radar (GPR) and borehole geophysics. Application of geochemical methods for mineral exploration: geochemical anomalies, background, threshold, pathfinder elements, geochemical methods: metallometric, hydrochemical, geobotanical and gas prospecting. Exploration openings: pitting and trenching, drilling and underground excavations, sampling and acquiring geological and geotechnical data.	**30**
Evaluation of deposits	Reserve estimation, grade calculation,workable standards. Economic, sub-economic and non-economic deposits.	**10**
Mineral Resources of Nepal	Geological controls, current status and future prospects of different mineral resources of Nepal. Metallic, nonmetallic and fossil fuels.	**15**

Text books:

1. Barrett W. M. et al. (2012): Introduction to mineral exploration, Blackwell Publication, 481p.

2. Kreiter V. M. (2004): Geological prospecting and exploration, University Press of the Pacific, 384p.
3. Rose, A. W., Hawakes, H. E. and Webb, J. S. (1970). Geochemistry for mineral exploration, Academic Press, 657 p.

Reference books:

1. ESCAP (1993): Atlas of mineral resources of Nepal, vol. 9, UN Publication.
2. DMG (2004): Mineral resources of Nepal.

B. Mining Geology

Total period: 75 Total Marks:50

Main Topics	Contents	Period
Introduction	Introduction to Minerals, Mines and Exploration Methods: Mineral resources, Mineral/Ore deposit/ prospect, Mine/ Quarry, Mining of Metallic and Nonmetallic Minerals: Ore Minerals, Industrial Minerals, Precious and Semi-precious stones, Dimension/ decorative stones, Construction Materials/Minerals. Fuel Minerals.	**2**
Mining Terminology	Mine opening, important parts of a mine, trench, pit, shaft, tunnel, adit, excavation, level, crosscut, stopping, loading, dumping, mine environment, mine ventilation, mineral transport system, mine drainage, light system, fire safety measures.	**10**
Mining methods and Technology	Definition, Mine and Mining, Stripping ratio, Ore and waste, Mine development, Mining plan, Mining methods and their selection, Type of Mines, Surface and Underground mine with examples from Nepal, Mine operation, Production, Sequences in the life of mine, Mine safety, Occupational health, Mine excavation.	**15**
Drilling and blasting methods, Mining equipments and machines	Shot hole drilling, Explosives, blasting methods, Excavator, loader, dumper, bulldozer, rock breakers.	**10**
Ore processing and dressing	Crushing, Grinding, washing, pulverizing, concentration, storage/stockpile/dumping site and waste management.	**8**
Mineral Industries	Basic infrastructures, mineral based industries examples, regular supply of materials (ore/ raw materials) to the industries, industrial production, quality of the product, quality control, regular supply in the market, market study.	**3**
Basic Mineral economics	Mine operation cost, production cost, market price/ selling price, internal and external price (ROM/CIF/FOB), Demand and supply situation, introduction to cost benefit analysis, Net Present value (NPV), Internal Rate of Return (IRR),	**15**

	Contribution to National GDP from mineral, mine, mining and Mineral industry sector.	
Existing Mines and Mineral Act	Existing Mines and Mineral Act-2042 and Mines and Mineral Regulations-2056, Lease system, Prospecting License, Mining License, Government Policy, License fee, surface rental, Government taxes, royalties, local taxes and benefits, royalty in production. Petroleum act-2040 and regulation-2041, environmental act-2053 and regulation-2054 with amendments.	**12**

Text books:

1. Marjoribanks, R., (2010): Geological Methods in Mineral Exploration and Mining, Springer-Verlag Berlin Heidelberg, 238p.
2. Peters, W. C., 1978. Exploration and Mining Geology, John Willy & Sons.
3. Cummins, A. B. and Given, I. A. (1973): Mining Engineering Hand Book. Society of Mining Engineers; New York.

Reference books:

1. Mines and Mineral Act 2042 BS and Mines and Mineral Regulation 2056.
2. Publications of Department of Mines and Geology, Journals and Bulletins of Nepal Geological Society and Central Dept. of Geology.
3. NGS website, DMG website, PEPP website etc.
4. Mines and Petroleum act-2040 and regulation-2041, environmental act-2053 and regulation-2054 with amendments.

B.Sc. IV Year
Geology (GEO.402)

Subject: Exploration Geology and Mining Geology

Nature of course: Practical | Course No.: Geo.402
Full marks: 50 | Total class period: 150
Pass marks: 17.5

A. Exploration Geology

Lab 1-6: Study of metallic and non-metallic economic minerals in hand specimens.
Lab 7-9: Study and interpretation of geophysical data related to mineral exploration.
Lab 10-12: Statistical analysis of geochemical data, preparation and interpretation of geochemical maps and sections.
Lab 13-16: Computation of ore reserves and grading of ores.
Lab 17-20: Study of geological controls of important economic deposits of Nepal and other countries from maps and sections.

B. Mining Geology

Lab 1-4: Draw diagrams of open pit/open cast and underground mine with examples from Nepal.

Lab 5-8: Calculation of grade and tonnage of an ore deposit on the basis of given data: surface trench and drill hole data and chemical analysis of ore samples.

Lab 9-12: Placer gold mining process and evaluation of placer gold deposit from given data.

Lab 13-16: Preparation of mining plan from given data.

Lab 17-20: Interpretation of the geophysical and borehole logging data.

Text and Reference books:

1. Babu, S. K. and Sinha, D. K. (1988): Practical manual of exploration and prospecting. CBS publishers, India, 167 p.
2. ESCAP (1993): Atlas of mineral resources of Nepal, vol. 9, UN Publication.
3. Smirnov, V. I. (1976): Geology of mineral deposits, Mir Publications.

B.Sc. IV Year
Geology (GEO.403)

Subject: Engineering Geology and Hydrogeology
Nature of course: Theory Course No.: Geo.403
Full marks: 100 Total class period: 150
Pass marks: 35

A. Engineering Geology

Total marks: 50 Total Period: 75

Main Topics	Contents	Period
Introduction to engineering geology	Development of engineering geology, aims of engineering geology, essential definitions.	**2**
Description, properties and behavior of soils and rocks:	Engineering soil classification, coarse soils, silts and loess, clay deposits, tropical soils, dispersive soils, soils of humid and arid regions, tills and glacially associated soil, frost action in soil, organic soils, peat, description of rocks and rock masses, engineering aspects of igneous, metamorphic and sedimentary rocks.	**5**
Geological materials	Important characteristics of geological materials, sediments, intact rock materials, fluids and gasses, description of geological materials, material properties and their measurement, types of test, limitations of testing, size and shape of sample, standards, density and unit weight, porosity and permeability, strength, types of rock deformation, consolidation of soils, Abrasiveness, environmental reactivity, index tests, range of values for soils and rocks, field test of soils and estimation of soil parameters.	**8**
Geological masses	Discontinuities, shear strength and discontinuities surface characteristics, field estimate of discontinuity friction angle, persistence, orientation, spacing, influence of weathering on rock mass properties, standard weathering description and weathering zonation, drilling and sampling in soils, drilling and sampling in soil and rocks, core logging for ground description.	**7**
Engineering geology of slopes	Landslides and their classifications, landslide recognition and identification, rate of landslide movement, extent of landslide, causes and mechanism of failures, the stability of slopes in soil, benching on slopes, slope drainage, effect of excavation technique on slope stability, slope stability analysis in rock, kinematic analysis of rock slopes, use of stereonets for rock slope failure analysis, rock mass rating (RMR) and Q-system, slope mass rating (SMR), severity of slope instabilities and remedial works.	**8**
Engineering	Published geological and engineering geological maps,	**6**

geological maps	engineering geological map making, understanding of geological maps, interpretation of geological maps for engineering purpose, mapping at a small scale, mapping at a large scale specially for foundation areas and excavations, rock slopes, outcrops, tunnels, mines, natural cavities, symbology in engineering geological maps, quality of published information	
Geological materials used in construction	Building or dimension stone, roofing and facing materials, armourstone, Crushed rock: concrete aggregate; road aggregate; gravels and sands; lime, cement and plaster; clays and clay products.	**5**
Excavation and ground loading	Excavation issues, blasting, ground improvement, site investigation for underground excavations, subsidence, types of foundation, ultimate bearing capacity, safe bearing capacity and allowable pressures, bearing capacities on boulder bearing soils, settlement on soils, bearing capacity on rock masses, foundation settlement on rock, Foundations on slopes.	**7**
Engineering geology and construction	Open excavation, tunnels and tunnelling, underground caverns, shafts and raises, reservoirs, dams and dam sites, highways, railroads, bridges, buildings.	**5**
Field tests and measurements	Tests in boreholes, tests in large diameter boreholes, shafts and tunnels, measurements in boreholes and excavations, choice of geophysical methods, seismic methods and their particular applications, use of electrical resistivity methods, magnetic methods and gravity methods in engineering geological site investigation.	**7**
Engineering geology and earthquakes	Characteristics of Earthquakes (magnitude, intensity), ground response analysis, assessing seismic risk and seismic hazard, ground engineering design against earthquake hazards.	**5**
Design and reporting of site investigations	Introduction, stages of Investigation, design of site investigations, progressive evaluation of site investigation data, investigation progress, supervision of investigating works, investigation reports, form of the report.	**5**
Engineering geology, planning and development	Introduction, geological hazards, risk assessment and planning, landslide hazard maps, derelict and contaminated land.	**5**

Text books:

1. 1. Price, D. G. and Freitas, M., (editors) (2008:) Engineering Geology - Principles and Practice, Springer, 460p.
2. 2. Bell, F. G. (2007): Engineering Geology, 2nd edition, Elsevier Publication, 583p.

Reference books:

3. Johnson, R. B. and Degraff, J. V. (1988): Principles of Engineering Geology, 1988, John Wiley Publication, 497p.
4. Dahal, R. K. (2006) Geology for Technical Students, Bhrikuti Academic Publications, 756p.
5. Hoek, E. (2014): Practical Rock Engineering Available in http://www.rocscience.com.

B. Hydrogeology

Total marks: 50 Total Period: 75

Main Topics	Contents	Period
Soil moisture and groundwater	Porosity of earth materials, classification of sediments, forces acting on groundwater, vertical distribution of groundwater, water table, infiltration, soil moisture, permeability of sediments.	**5**
Geology of groundwater occurrence	Aquifers, types of aquifers, Unconsolidated aquifers (alluvial valleys, alluvium in tectonic valleys) Rocks as aquifers.	**8**
Groundwater exploration	Surface and subsurface investigations of groundwater: Geological methods, remote sensing, test drilling, geophysical logging (resistivity logging, spontaneous potential logging and other subsurface methods.	**8**
Groundwater movement	Darcy's Law, groundwater flow rates, specific yield, hydraulic conductivity of earth materials (Darcy's experiment, hydraulic conductivity, permeability of sediments, permeability or rocks), storage coefficient, effective porosity, groundwater flow directions, general flow equations.	**10**
Water wells	well drilling methods (direct rotary, reverse rotary, percussion, down the hole, types and applications of drilling fluids, well screens and their types and method of sediment size analysis, water well designs, casing diameter, casing materials, well depth, well screen length, well screen slot openings, open area, entrance velocity, design of wells. Installation and removal of well screens, well development methods, aquifer development techniques, factors that affect development. Pumping test, conducting a pumping test, measuring drawdown in wells, well efficiency, step drawdown test, problems of pumping test analysis. multiple well systems, well losses and specific capacity, Thiem equation, Theis equation, Cooper-Jacob equations, Hantush equations and their applications. Water well pumps:	**22**
Groundwater quality and pollution	Sources of salinity, measures of water quality, chemical analysis, Graphic representations, physical analysis, biological analysis, groundwater samples, water quality criteria, changes in chemical composition, dissolved gases, temperature, water pollution due to mining, agricultural sources of pollution. Water quality protection for wells and nearby groundwater resources.	**7**
Groundwater development and management	Dynamic equilibrium in natural aquifers, groundwater budgets, management of potential aquifers, water law, conjunctive use of groundwater and surface water. Groundwater monitoring technology, artificial recharge, groundwater modelling,	**7**
Groundwater resources of Nepal	Distribution, utilization, quality, and management. Types of aquifer and springs in different geological regions of Nepal. Groundwater legislation.	**8**

Text book:

1. Todd, D.K., Mays, W.M. (2005): Groundwater Hydrology. John Wiley & Sons, New York, third edition
2. Driscoll, F. G., (1989): Groundwater and wells, Johnson Filtration Systems Inc., Minnesota.

Reference books:

1. Freeze R. A., Cherry J. A. (1979): Groundwater, Prentice Hall.
2. Fetter, C.W. (1994): Applied Hydrogeology. Macmillan, New York

B.Sc. IV Year
Geology (GEO.404)

Subject: Engineering Geology and Hydrogeology

Nature of course: Practical | Course No.: Geo.404
Full marks: 50 | Total class period: 150
Pass marks: 17.5

A. Engineering Geology

Lab 1-10: Determination of index properties of soil and rock (Natural moisture contents, grain size distribution, hydrometer analysis, Atterberg Limits, Unit weight, Specific Gravity, Permeability test, direct shear, point load test).
Lab 11-12: Evaluation of mechanical properties of aggregates.
Lab 13-16: Selection of possible sites using topographic maps for dams, tunnels, bridges, highways and other civil engineering structures.
Lab 17-20: Analysis of engineering geological data for solving engineering problems.

B. Hydrogeology

Lab 1-2: Determination of water content of soils.
L**ab 3-7**: Preparation of groundwater flow maps and determination of flow directions.
Lab 8-10: Calculation of groundwater storage potentials.
Lab 11-15: Analysis of pumping test data to calculate aquifer parameters.
Lab 16-20: Analysis and presentation of groundwater quality parameters for drinking and domestic use of groundwater resources.

B.Sc. IV Year
Geology (GEO.406)

Subject: Field Work

Nature of course: Practical | Course No.: Geo.406
Full marks: 100 | Total class period: 320
Pass marks: 35 | Field work duration: 28 days

General Objectives: The principal objectives of filed work are to introduce students to various geological rock successions of the Nepal Himalaya, and to familiarize them various criteria and techniques to study geological elements to produce geological maps of 1:25,000-scale.

There will two MODULES in the field work.

Module I	Module II
Full marks: 50	Full marks: 50
Duration: 14 days	Duration: 14 days

Course Load: 7 hours per day per teacher**.**
Field Report: Each student should submit field report individually after completion of the field work

A. Field Work Module I (14 days)

General objectives:

- Geological study of the Siwalik Group and the Quaternary Sediments
- Geological study of the Lesser Himalayan succession

Specific objectives:

To carry out the following tasks

- Field techniques of recording lithological information: composition, texture, and structure of rocks:
  - Maintaining Field Diary, Graphic logging, Sketching, etc.
  - Measuring paleocurrent data,
  - Sampling and describing rocks and fossils
  - Route mapping
- Delivering concept on order of superposition, and correlation of rock units
  - Using various sedimentary structures and cross-cutting relations of geological structures
  - Using concept of litho- and bio-stratigraphic correlations
- Identifying various geological structures in the field
  - Joints, lineation, foliation, fault, fold, unconformity, etc.
- Understanding the criteria of lithostratigraphic sub-division of geological units
  - Preparation of lithostratigraphic columns
  - Classification of successions into different units (Bed, Member, Formation, Group, Supergroup)
- Studying geological mapping techniques after following all the previous mentioned tasks

- Producing a geological map and a geological cross-section
- Interpreting various geological structures, and litho-stratigraphic units

Subtitles of Module I

	Subtitle of Module I	Fieldwork marks
A	Study of geology of the Siwalik Group and Quaternary Sediments: Lithostratigraphy, sedimentology, fossil occurrence, geological structures, and geological mapping	25
B	Study of geology of Proterozoic-Early Cenozoic successions (Kaligandaki Supergroup and Tansen Group of western Nepal or similar successions of mid-western or eastern Nepal Lesser Himalaya): Lithostratigraphy, sedimentology, fossil occurrence, geological structures, and geological mapping	25

Field Work Plan

	Subtitle of Module I
	Day 1: Departure to Field work area and Field orientation and preparation
A	Study of geology of the Siwalik Group and Indo-Gangetic Plain:
	Day 2: Traverse within the Indo-Gangetic Plain
	Day 3: Traverse within the Lower-Middle Siwaliks
	Day 4: Traverse within the Middle-Upper Siwaliks Day 5:Geological Route Mapping in an appropriate scale
B	Study of geology of Proterozoic-Early Cenozoic successions (Kaligandaki Supergroup and Tansen Group of western Nepal or similar successions of mid-western or eastern Nepal Lesser Himalaya):
	Day 6: Traverse within the Proterozoic-Early Cenozoic successions (mainly Kaligandaki SG or equiv.)
	Day 7: Traverse within the Proterozoic-Early Cenozoic successions (mainly Kaligandaki SG or equiv.)
	Day 8: Traverse within the Proterozoic-Early Cenozoic successions (mainly Tansen Group or equivalent)
	Day 9: Traverse within the Proterozoic-Early Cenozoic successions (mainly Tansen Group or equivalent)
	Day 10: Geological Route Mapping in an appropriate scale
	Day 11: Individual Group Field work: Geological Mapping in 1:25,000 scale
	Day 12: Individual Group Field work: Geological Mapping in 1:25,000 scale
	Day 13: Field Report writing
	Day 14: Field Report submission and Field viva. Retreat from the field to College

B. Field Work Module II (14 days)

General objectives:

- to familiarize students with

- methods of mineral Exploration and mining (EXPLORATION AND MINING GEOLOGY)
- various techniques of characterizing properties of soil and rock, and to prepare engineering geological maps (ENGINEERING GEOLOGY)
- groundwater exploration technique such as bore hole drilling, and estimating discharge and recharge (HYDROGEOLOGY)

Specific objectives:

- To familiarize students with various techniques of characterizing properties of soil and rock, and to prepare engineering geological maps (ENGINEERING GEOLOGY)
  - To classify soils using USCS
  - To classify rocks using RMR, Q-system, GSI, Rmi
  - Technique of preparing Engn Geol. map for road or tunnel or canal alignment
  - Technique of preparing Engn. Geol. maps and profiles of landslides; Factor of Safety Analysis
- to familiarize students with groundwater exploration technique such as bore hole drilling, and estimating discharge and recharge (HYDROGEOLOGY)
  - Technique of bore hole drilling: equipments and method
  - Logging bore hole: Litho logging, geophysical well logging
  - Techniques of estimating discharge: wells and springs
  - Techniques of estimating recharge: wells and ponds
- To familiarize students with exploration methods, evaluation of deposits, mining and processing methods (EXPLORATION AND MINING GEOLOGY)
  - Introducing mineral exploration and Sampling techniques of ore minerals, minerals, rocks and rock materials.
  - Mapping of a reserve in an appropriate scale, Estimation of reserve
  - Introducing a quarry site, equipments, and quarry methods
  - Introducing mineral or rock processing (e.g., limestone processing)

Field work subtitles based on course load

	Subtitle of Field Work Phase II	Subject	Field work marks
A	(a) To familiarize students with various techniques of characterizing properties of soil and rock, and to prepare engineering geological maps	ENGINEERING GEOLOGY	12.5
	(b) To familiarize students with groundwater exploration technique such as bore hole drilling	HYDROGEOLOGY	12.5
B	To familiarize students with exploration methods, evaluation of deposits, mining and processing methods	EXPLORATION AND MINING GEOLOGY	25

		Days
	Day 1: Departure to Field work area and Field orientation and preparation	1
A	**(a) Techniques of characterizing properties of soil and rock, and to prepare engn. geol. maps**	
	Day 2: Characterization of soil and rock mass including Technique of preparing	

	Engn Geol. maps	
	Day 3: Technique of preparing Engn. Geol. maps for road or tunnel or canal alignment including characterization of soil and rock mass	
	Day 4: Technique of preparing Engn. Geol. maps and profiles of landslides; Factor of Safety Analysis	3
A	**(b) To familiarize students with groundwater exploration technique such as bore hole drilling**	
	Day 5: Technique of bore hole drilling: equipments and method; Logging bore hole	
	Day 6: Hydrogeological investigation	
	Day 7: Estimation of discharge and recharge	3
B	**To familiarize students with exploration methods, evaluation of deposits and mining methods**	
	Day 8: Introducing mineral exploration and Sampling techniques	
	Day 9: Mapping of ore bodies and host rocks in an appropriate scale	
	Day 10: Mapping of ore bodies and host rocks in an appropriate scale and reserve estimation	
	Day 11: Study of mining sites and observation of mining equipment and mining methods	
	Day 12: Study of ore processing and dressing in industrial plants	5
	Day 13: Field Report writing	1
	Day 14: Field Report submission and Field viva. Retreat from the field to College	1
		Days
	Day 1: Departure to Field work area and Field orientation and preparation	1
A	**(a) Techniques of characterizing properties of soil and rock, and to prepare engn. geol. maps**	
	Day 2: Characterization of soil and rock mass including Technique of preparing Engn Geol. maps	
	Day 3: Technique of preparing Engn. Geol. maps for road or tunnel or canal alignment including characterization of soil and rock mass	
	Day 4: Technique of preparing Engn. Geol. maps and profiles of landslides; Factor of Safety Analysis	3
A	**(b) To familiarize students with groundwater exploration technique such as bore hole drilling**	
	Day 5: Technique of bore hole drilling: equipments and method; Logging bore hole	
	Day 6: Hydrogeological investigation	
	Day 7: Estimation of discharge and recharge	3
B	**To familiarize students with exploration methods, evaluation of deposits and mining methods**	
	Day 8: Introducing mineral exploration and Sampling techniques	

	Day 9: Mapping of ore bodies and host rocks in an appropriate scale	
	Day 10: Mapping of ore bodies and host rocks in an appropriate scale and reserve estimation	

B.Sc. IV Year
Geology (GEO.407)

Subject: Fundamentals of Economics and Management

Nature of course: Theory (Interdisciplinary) Course No.: Geo.407
Full marks: 50 Total class period: 75
Pass marks: 17.5

A: Economics

Main Topics	Contents	Period
Introduction	Origin of Engineering Economy, Principles of Engineering Economy, Role of Geologists in Decision Making, Cash Flow Diagram.	
Interest and Time Value of Money	Introduction to Time Value of Money, Simple Interest, Compound Interest, Nominal Interest rate, Effective Interest rate, Continuous Compounding, Economic Equivalence, Development of Interest Formulas, The Five Types of Cash flows, Single Cash flow Formulas, Uneven Payment Series, Equal Payment Series, Linear Gradient Series, Geometric Gradient Series.	
Basic Methodologies of Engineering Economic Analysis	Determining Minimum Attractive (Acceptable) Rate of Return (MARR), Payback Period Method, Equivalent Worth Methods, Present Worth Method, Future Worth Method, Annual Worth Method, Rate of Return Methods, Internal Rate of Return Method, External/Modified Rate of Return Method, Public Sector Economic Analysis (Benefit Cost Ratio Method). Introduction to Lifecycle Costing, Introduction to Financial and Economic Analysis.	
Comparative Analysis of Alternatives	Comparing Mutually Exclusive Alternatives having Same useful life by Payback Period Method and Equivalent Worth Method, Rate of Return Methods and Benefit Cost Ratio Method, Comparing Mutually Exclusive Alternatives having different useful lives by Repeatability Assumption, Co-terminated Assumption, Capitalized Worth Method, Comparing Mutually Exclusive, Contingent and Independent Projects in Combination.	
Replacement Analysis	Fundamentals of Replacement Analysis, Basic Concepts and Terminology, Approaches for Comparing Defender and Challenger, Economic Service Life of Challenger and	

	Defender, Replacement Analysis When Required Service Life is Long, Required Assumptions and Decision Framework, Replacement Analysis under the Infinite Planning Horizon, Replacement Analysis under the Finite Planning Horizon.	
Risk Analysis	Origin/Sources of Project Risks, Methods of Describing Project Risks, Sensitivity Analysis, Breakeven Analysis, Scenario Analysis, Probability Concept of Economic Analysis, Decision Tree and Sequential Investment Decisions.	
Depreciation and Corporate Income Taxes	Concept and Terminology of Depreciation, Basic Methods of Depreciation, Straight line method, Declining Balance Method, Sinking Fund Method, Sum of the Year Digit Method, Modified Accelerated Cost Recovery System (MACRS), Introduction to Corporate Income Tax, After Tax Cash flow Estimate. General Procedure for Making After Tax Economic Analysis.	
Inflation and Its Impact on Project Cash flows	Concept of Inflation. Measuring Inflation, Equivalence Calculation Under Inflation, Impact of Inflation on Economic Evaluation.	

B: Management

Main Topics	**Contents**	**Period**
Introduction to management:	Concept, meaning and essence of management, Functions of Management, Types of Managers, Managerial Roles and Skills, Becoming a Manager: Role of Education, Experience and Situation, Business and Society, Corporate Social Responsibility, Ethics and Ethical Standards, Corporate Governance.	
Perspectives in Management	Early Developments, The Classical perspective, The Behavioral Perspective, Quantitative Perspective, Integrating Perspective, Contingency Perspective, Contemporary Perspective on Management, Emerging Management Issues and Challenges.	
Planning and Decision Making:	Planning: Meaning of Planning, The Planning System, Levels of Planning, Hierarchy of Plans, Steps in Planning, Tools for Planning, Planning Premises, Pitfalls of Planning, Improving Planning. Decision Making: Meaning and Concept, Types of Decisions, Decision Making Process, Decision Making Conditions.	
Organizing and Staffing:	Organizing: Meaning of Organizing, Principles of Organizing, Process of Organizing, Organizational Architecture, Vertical Differentiation, Horizontal Differentiation, Responsibility, Authority, Delegation of Authority, Centralization, Decentralization and Devolution. Staffing: Concept of Staffing,	

	Stafffing and Human Resource Management, Objectives of Staffing, Importance of Staffing, Components of Staffing Function.	
Leadership, Motivation and Communication:	Meaning of Leadership, Qualities of Leadership, Understanding Individual Differences and Psychological Contacts, Leadership Styles. Concepts of Work Groups. Managerial Ethics. Concept of Motivation, Importance of Motivation, Techniques of Motivation. Meaning of Communication, Importance of Communication in Organizations, Purpose of Organizational Communication, The Communication Process, Communication Networks, Concept of Active Listening, Communication Flows in Organizations, Types of Communications, Barriers of Effective Communications, Enhancing Organizational Communication.	

Text and Reference Books:

1. Chan S. Park, Contemporary Engineering Economics, Prentice Hall, Inc.
2. PR Pant, 2014. Principles of management. Buddha Academic Publishers and Distributors Pvt. Ltd.
3. Paul De Garmo, William G. Sullivan and James A. Bonta delli, Engineering Economy, MC Milan Publishing Company.
4. James L. Riggs, David D. Bedworth and Sabah U. Randhawa, Engineering Economics, Tata MCGraw Hill Education Private Limited.
5. GS Gupta (2011), Managerial economics, Tata McGraw Hill Education Pvt. Ltd. New Delhi. 432p.
6. MS Bhat and AV Rau (2008), Managerial Economics and Financial Analysis, BS Publications, Hyderabad, 364p.