Institute of Science and Technology

Master of Science in Geology

M.Sc. Geology

Curriculum

1999

Curriculum Development Centre

Tribhuvan University

Kirtipur, *Kathmandu*

Nepal

Publisher:

Curriculum Development Centre
Tribhuvan University
Kirtipur, Kathmandu,
Nepal
Tel. No. 330856

First Edition:

Kartic, 2056
October, 1999

Price: Gunacc

Funded by: GIFT
Higher Education Project
T.U.

Printers:

Master of Science in Geology

M.Sc. Geology

Effective from 1999

Office of the Dean
Institute of Science and Technology
Tribhuvan University
Kathmandu, Nepal

Introduction

The three-year Bachelor level educatioin has been introduced in the Tribhuvan University in order to make the level of education at par with the enternational standards. This has necessitated modifying and revision the present syllabus for Master's degree. Consequently, the Course of Study on Master of Science in Geology is revised to meet the above requirements.

Aims and objectives

The main aim of the Course is to create the professionals having in-depth knowledge and skills in the field of geology. Apart from it the Course also aims at producing specialists able to follow integrated and multi-disciplinary approches in their profession.

After the completion of the M.Sc. course in geology, the students will be qualified as geologists. They will be able to carry out the professional work, research, and/or advanced studies independently.

Eligibility for Admission

The candidates who have passed the B.Sc. course in Geology from the Tribhuvan University or the B.Sc. course in Geology from any othre equivanlent universities or institutions shall be considered eligible for admission to the M.Sc. course in Geology. They should have also attended the prescribed geological dield training at the B.Sc. level.

Admission Criteria:

The applicants will have to appear in an entrance examination of two hours' duration conducted by the Central Department of Geology. An applicant who fails to appear in the Entrance Examination or fails to obtain a minimum qualifying score will not be allowed admission. A merit list of the qualified applicants will be prepared on the basis of the percentage of marks in their B. Sc. Examination and the marks obtained by them in the Entrance Examination. Admission of the students will be based strictly on the merit list and the enrollment capacity of the Central Department of Geology.

Course Structure

The M.Sc. course in geology will run for two academic years. The total aggregate of marks for the two-year coure will be 1000 as per the distribution indicated below (Tables 1, 2 and 3.)

Candidates shall be examined at the end of each year in the respective courese of theory, practicals, and fieldwork. The marks allocated, periods per week, and the duration of the examination for the theory and practical papers are shown in Table 1.

Table 1: Periods per week, marks allocated, and duration of examination for various papers

Paper	Marks allocated		Periods per week		Examination duration	
	Theory	Practical	Theory	Practical	Theory	Practical
Full Paper	70	30	4	6	4 Hours	6-8 Hours
Half Paper	35	15	2	3	2 Hours	3-4 Hours
Half Paper	50	-	3	-	2 Hours	
Project/Course work	15		not applicable		Assessment	
Field work	50		56		Assessment	
Dissertation	100		not applicable		Assessment	

Fieldwork and Dissertation

Fieldwork for a period of 8 weeks will be given to each student of the M.Sc. course in Geology. There will be two fieldworks of four weeks of duration (one in the First Year and the other in the Second Year) and each of them will carry 50 marks.

The candidate shall have to select in the Second Year one Steam of Specialisation including corresponding preacticals and fieldwork as well as a compulsory dissertation. The dissertation will ordinarily include from four to six weeks of fieldwork.

The dissertation will be submitted to the Scientific committee of the central Department of Geology. The dissertation will be examined by the scientific Committee according to the rules and regulations of the Committee. the date for the defence of the dissertation will be fixed by the Scientific Committee of the central Department of Geology, Tribhuvan University, generally about 4 months after the M.Sc. Second Year examinations.

M.Sc. Geology First year

In M.Sc. First Year, the courses will be compulsory for all the students. The allocation of marks are shown in Table 2.

Table 2: Allocaion of marks for M.Sc. First Year
Master of Science in Geology
Theory

Course No.	Courses Title	Full Marks	Pass Marks
GEO. 511	Igneous and Metamorphic Petrology	70	28
GEO. 512a	Sedimentology	35	14
GEO. 512b	Geomorphology	50	20
GEO. 513a	Introduction to Geophysics	35	14
GEO. 513b	Concepts of Mineralogy and Geochemistry	35	14
GEO. 514a	Structural Geology	35	14
GEO. 514b	Geology of Himalayas	50	20
GEO. 515a	Project Management	35	14
GEO. 515b	Fieldwork	50	14

Practical

Course No.	Courses Title	Full Marks	Pass Marks
GEO. 516	Igneous and Metamorphic Petrology	30	12
GEO. 517	Sedimentology	15	06
GEO. 518a	Intoduction to Geophysics	15	06
GEO. 518b	Concepts of Mineralogy and Geochemistry	15	06
GEO. 519	Structural Geology	15	06
GEO. 520	Project Management Project work	15	06

M.Sc. Gelology Second Year

In M.Sc. Second Year, there will be three Streams of Specialisation and the students whall choose one of them. the details of allocatin of marks for each stream are shown in Tables 3a, 2b, and 3c, respectively.

Table 3a: Allocation of marks for M.Sc. Second year
Stream: Natural Resources Studies

Theory

Course No.	Courses Title	Full Marks	Pass Marks
GEO. 611	Mineral Resources	70	28
GEO. 612a	Advanced Techniques of Mineralogy	35	14
GEO. 612b	Geochemical exploration and environmental geochemistry	35	20
GEO. 613a	Mineral Economics and Agricultural Geology	50	14
GEO. 613b	Mining Geology and Underground Excavations	50	14
GEO. 614a	Photogeology, Geoinformatics and Mapping Techniques	35	14
GEO. 614b	Fieldwork	50	20

Practical

Course No.	Courses Title	Full Marks	Pass Marks
GEO. 615	Mineral Resources	30	12
GEO. 616a	Advanced Techniques of Mineralogy	15	06
GEO. 616b	Geochemical exploration and environmental geochemistry	15	06
GEO. 617	Photogeology and Geoinformatics	15	06
GEO. 618	Dissertation	100	40

Table 3b: Allocation of marks for M.Sc. Second year
Stream: Mapping and Analysis
Theory

Course No.	Courses Title	Full Marks	Pass Marks
GEO. 621	Global Tectonics and Basin Analysis	70	28
GEO. 622a	Geohazards and Environmental Geology	50	14
GEO. 622b	Groundwater Hydrology	35	20
GEO. 623a	Palaeontology	35	14
GEO. 623b	Techniques of Structural Analysis	35	14
GEO. 624a	Photogeology, Geoinformatics,and Mapping Techniques	35	14
GEO. 624b	Fieldwork	50	20

Practical

Course No.	Courses Title	Full Marks	Pass Marks
GEO. 625	Global Tectonics and Basin Analysis	30	12
GEO. 626	Groundwater Hydrology	15	06
GEO. 627a	Palaeontology	15	06
GEO. 627b	Techniques of Structural Analysis	15	06
GEO. 628	Photogeology, Geoinformatics, and Mapping Techniques	15	15
GEO. 629	Dissertation	100	40

Table 3c: Allocation of marks for M.Sc. Second year
Stream: Engineering Geological Techniques
Theory

Course No.	Courses Title	Full Marks	Pass Marks
GEO. 631	Engineering Geology and Geotechniques	70	28
GEO. 632	Engineering Geophysics	70	28
GEO. 633a	Engineering Hydrology	50	20
GEO. 633b	Groundwater Hydrology	35	14
GEO. 634a	Remote Sensing and Geoeinformatics	35	14
GEO. 634b	Fieldwork	50	20

Practical

Course No.	Courses Title	Full Marks	Pass Marks
GEO. 635	Engineering Geology and Geotechniques	30	12
GEO. 636	Engineering Geophygsics	30	12
GEO. 637	Groundwater Hydrology	15	06
GEO. 638	Remote Sensing and Geoeinformatics	15	15
GEO. 639	Dissertation	100	40

Course Duration:
Candidates shall be examined at the end of each year in the respective courses of theory, practicals, and fieldwork. The duration of the examination for the theory and practical papers will be four hours.

Hours of Instruction:

a) Working days	:	180 days in an academic year.
b) Class hour	:	
i) Theory:		One theory paper of 70 marks will have 4 hours' lecture per week and of 50 marks and 35 marks will have 2 hours' lecture per week.
ii) Practical:		One practical paper of 30 marks and 15 marks will have 18 hours and 9 hours of practicalper week respectively.
c) Attendance	:	70 percent attendance in the class is compulsory.

Examination:
The Institute of Science and Technology, Tribhuvan University , will conduct the annual examinations. The students will have to pass examination of each level and each course member separately. The minimum pass marks are 40 percent both for theroretical, practical, and field classes.

All students will have to appear in four hours' examination for theoretical courses carrying 70 marks and two hours' examination for theoretical courses carrying 50 marks and 35 marks. There will be six hours' practical examination for 30 marks and three hours' practical examination for 15 marks.

Evaluation :
Institute of Science and Technology, Tribhuvan University will conduct annual examinations. The students will have to pass each level and each course numbers separately. The minimum pass marks is 40 percent both for theory and practical.

A student having passed his / her two years of study will be graded on the basis of the two years' average marks as follows:

75	per cent	Distinction
60	per cent and above	First Division
50	per cent and above	Second Division
40	per cent and above	Third Division

Table 2: M.Sc. First Year

Theory

Course No.	Courses Title	Full Marks	Pass Marks
GEO. 511	Igneous and Metamorphic Petrology	70	28
GEO. 512a	Sedimentology	35	14
GEO. 512b	Geomorphology	50	20
GEO. 513a	Introduction to Geophysics	35	14
GEO. 513b	Concepts of Mineralogy and Geochemistry	35	14
GEO. 514a	Structural Geology	35	14
GEO. 514b	Geology of Himalayas	50	20
GEO. 515a	Project Management	35	14
GEO. 515b	Fieldwork	50	14

Practical

Course No.	Courses Title	Full Marks	Pass Marks
GEO. 516	Igneous and Metamorphic Petrology	30	12
GEO. 517	Sedimentology	15	06
GEO. 518a	Intoduction to Geophysics	15	06
GEO. 518b	Concepts of Mineralogy and Geochemistry	15	06
GEO. 519	Structural Geology	15	06
GEO. 520	Project Management Project work	15	06

Course Title: Igneous and Metamorphic Petrology **Full Marks: 70**
Course No.: GEO 511 **Pass Marks: 28**
Nature of the course: Theory **Year: First**

Course Description: This course provides the students with the concepts of igneous and metamorphic petrology. It deals with the igneous and metamorphic rocks, their origin, occurrence, and distribution in space and time.

General Objective: To provide in-depth understanding of igneous and metamorphic rocks and their processes of formation and evolution.
Specific Objective: To provide the students with in-depth knowledge and practical skills of

- magmatism,
- metamorphism, and
- modern methods of study and analysis of igneous and metamorphic rocks.

Course Contents:
Introduction
The earth and its magmatism: The early evolution of the earth. Isotopic evolution of the crust and mantle. Compositional evolution of the crust and mantle. The earth's igneous activity today. The nature of mantle.
Magmas and igneous rocks: Composition, physical properties of magmas, effects of cooling and crystallization, Transfer of mass and energy by diffusion, Flow of magma in the mantle and crust, Convection.
Crystal-liquid relations: Some basic thermodynamic relations, Equilibrium in reversible or irreversible process, One component systems. The principle of Le Chatalier, The phase rule, Two component systems, Three component systems, Systems of four or more components.
Igneous minerals and their textures: Common igneous minerals. Crystallization of igneous minerals. Textures of igneous rocks. Magmatic differentiation. Mechanism and effect. Mechanism of differentiation, Fractionation by melting, Liquid- liquid fractionation, Assimilation, Liquid-vapour fractionation, Combined mechanisms of differentiation, Compositional effects of differentiation, Trace elements and differentiation, Kinetic effects. Basic intrusion. Dolerite sills, Forms and mode of emplacement of layered intrusions.
Basalt and magma series: Chemical and petrographic characteristic. Example of tholeiitic and alkaline series. The origin of magma series. Origin of magma series. Mantle origin of basalt. Mechanism of magma generation. Mineralogical composition of source rock in the mantle. Ultra mafic inclusion. Melting of high pressure. Primary melts of the mantle
Oceanic and flood basalts: Tectonic and structural settings. Eruptive behavior. Orogenic volcanic rocks. Example of orogenic volcanic province. Shallow differentiation. Experimental studies of calc-alkaline rocks. Origin of calc-

alkaline magma. The role of subducted crust. Generation and rise of subduction related magma.

Granitic plutons and siliceous ignimbrite: Petrographic and mineralogic classification, Chemical classification, Crustal environment and internal structure, Tectonic settings, Plutonic rocks of Precambrian ages, The granite systems, Generation and rise through the crust, Melting behavior of natural rocks, Crystallization and differentiation in the crust, Origin of granitic and rhyolitic magma, Geological and geochemical evidence, Granite and crustal problems.

Alkaline rocks of continental interior: Alkaline and peralkaline series, Alkaline and peralkaline series of continental rifts, Carbonilites and related rocks, Lamprophyres, Kimberlites, Melting relation at high pressures, Ultra potassic series, Mantle origins of intra-plate alkaline magma.

The concept of metamorphism: The development of modern ideas of metamorphism. Type of metamorphic bodies. Composition, Fabric, Classification of rocks, Description of metamorphic rock types, Composition. Field relation of metamorphic change. Metamorphic studies in geology, some examples of metamorphism. The settings of metamorphism. The controlling factors of metamorphism.

Chemical Equilibrium in Metamorphism: Equilibiruim - an introduction, the phase rule. Metamorphic phase diagram. Application of the phase rule to natural rocks. Metamorphic reactions - some first principles. Metamorphic reactions - some second thoughts. The influence of fluids on metamorphic phase equilibria. Application of chemical equilibrium to natural rocks: an example. Evidence for equilibrium in metamorphism: summary and critique. Metamorphic facies. Determination of pressure - temperature conditions of metamorphism.

Metamorphism of pelitic rocks : Representation of pelite assemblages on phase diagrams. Pelitic rocks at low grades. Metamorphism of pelite in the Barrovian zonal scheme. Variation on the Barrovian zonal pattern, High temperature metamorphism of pelites, Metamorphism of pelites at low pressures, Metamorphism of pelites at high pressures. Pressures and temperatures of metamorphism of pelitic rocks.

Metamorphism of Basic Igneous Rocks: The facies classification. Metamorphism of basic rocks at low grades: zeolite and prehnite - pumpellyite facies. Metabasites from the Barrovian zones: greenschist and amphibolite facies. Effects of lowered pressure: hornfels facies. Basic igneous rocks metamorphosed at high pressures: blueschist and eclogite facies. High temperature metamorphism: granulite facies. The P-T conditions of formation of metabasic rock types. Hydrothermal metamorphism of basaltic rocks.

Metamorphism of Marbles and Calc-Silicate Rocks: Marbles, Calcite marbles, Dolomitic marbles. Controls on the fluid composition in marbles. A petrogenetic grid for reactions in marbles. Metamorphism of calc-silicates.

Metamorphic textures and processes: Metamorphic textures - the underlying principles, Diffusion in solids, Nucleation and growth of mineral grains. The textures of metamorphic rocks, Textures of recrystallisation, Textures of crystallisation. Disequilibrium textures. Metamorphic textures as a guid to the

mechanism of metamorphic reactions. The influence of rock deformation on metamorphic textures and processes. Relationships between metamorphism and deformation, Metamorphic textures and the relative timing of metamorphism and deformation, Interactive relationships between metamorphism and deformation. Rates of metamorphic processes. The duration of a metamorphic cycle. Rates of metamorphic reactions.

The Relationships between Regional Metamorphism and Tectonic Processes: Metamorphism, geothermal gradient and paired metamorphic belts. Plate tectonic interpetation of paired metamorphic belts. Modern convergent margins: implications for metamorphism. Time as a variable in metamorphism. Preservation of high pressure rocks after metamorphism. Tectonic setting of low pressure metamorphism. Metamorphism and continental collision. Metamorphism related to ophiolites. Variation in metamorphism through geological time.

Course Title: Igneous and Metamorphic Petrology Full Marks: 30
Course No.: GEO 516 Pass Marks: 12
Nature of the course: Practicals Year: First

Igneous Petrology: Study of mineralogical composition and textural charactersitics of ingneous rocks in handspecimen and thin sections.
Determination of refractive indeces of minerals with the help of liquids.
Chemical anlysis (major elements) of representative rocks and calculation of norms.
Metamorphic petrology: Study of mineralogical compotion and textures of metamorphic rocks in handspecimen and thin sections. Paragenetic interpretation.
Model analyis, chemical analysis, and calculation of ACF, AFM, and other diagrams.
Chemical analysis of minerals an geothermobarometric calculations.

Textbooks:

1. Best M. G. (1986): *Igneous and Metamorphic Petrology*, CBS Delhi, 639 p.
2. Hyndman D. W. (1985): *Petrology of Igneous and Metamorphic Rocks*, McGraw Hill Inc., 786 p.
3. Yardley B. W. D. (1990): *An Introduction to Metamorphic Petrology*, ELBS, 248 p.
4. McBirney A.R. (1993): *Igneous Petrology*, Jones and Bartlett Publishers, Inc., 508 p.

Reference Books:

1. Hall A. (1988): *Igneous Petrology*, ELBS, 573 p.
2. Winkler H. G. F. (1987): *Petrogenesis of Metamorphic Rocks, 5th edition*, Narosa Publishing House Delhi, 348 p.
3. Phillpots, A. R.: *Principles of Igneous and Metamorphic Petrology* (1994) , Hall of India Pvt Ltd.,498p
4. Miyashiro A. (1994): *Metamorphic Petrology*, UCL, 404 p.
5. Thrope R. S. and Brown G. C. (1995): *The Field Description of Igneous Rocks*, John Weiley & Sons, 154 p.
6. Carmichael I. S. F., Turner F. J., and Verhoogen J. (1974): *Igneous Petrology*, McGraw Hill Inc., 739 p.
7. Hutchinson (1974): *Laboratory Methods in Petrography*, John Wiley and Sons, New York, 527p

Sedimentology

Course Title: Sedimentology **Full Marks: 35**
Course No.:GEO.512a **Pass Marks: 14**
Nature of the course: Theory **Year: First**

Course Description: This course provides the students with the concepts of sedimentology. It deals with the sediments and sedimentary rocks, their origin, occurrence, and distribution in space and time.

General Objective: To give in-depth knowledge and understanding of sediments and sedimentary rocks.

Specific Objective: To provide the students with in-depth knowledge and practical skills of

- Textures and structures of sedimentary rocks,
- Environment of deposition of sediments
- Physical, chemical, and biological processes of sediment formation, transport, deposition, and diagenesis.

Course Contents:

Physical Basis of Sedimentology : Introduction to sedimentology, Primary structures and textures, Physical parameters: Structures, Sediment grain movement, Mode of sediment transport.

Hydrodynamic factors and bedforms in water: Flow regime, Lower flow regime, Transition regime, Upper flow regime, Bedforms, Sediment movement, Sand waves, Transport, Migration of bedforms, Stream power and water depth.

Current and wave ripples: Internal structure of a ripple, Megaripple and microdeltas, Development of lamination in the lee face, Varibles controlling the shape and slope of foreset, Sediment movement in symmetrical wave ripples, Sediment movement in asymmetrical wave ripples, Wave ripples, Current ripples, Combined current/ Wave ripples, Isolated ripples, Wind ripples.

Surface markings and imprints, Scour marks, Tool marks, Penecontemporaneous deformation structures,

Bedding: General information, Cross-bedding, Climbing-ripple lamination, Flaser and lenticular bedding, Gradded bedding,

Sediment grain parameters: Shape and roundness of sediment grains, Surface texture of sediment grains, Primary fabric of grain orientation.

Chemical and mineralogical parameters, Biological parameters, Environmental reconstructions.

Classification of Sediments and Sedimentary rocks: Siliciclastic and carbonate rocks. Conglomerates, sandstones, and mudrocks.

Depositional environments: Introduction: General information. Importance of sequence in environmental reconstruction

Glacial environment: General information, Eskers, Kames, Small-delta deposites, Glacial lake deposits, Sandur deposits, Interglacial deposits, Evidences of glacial activity, Plains.

Desert environment: Erosion and sedimentation processes in the desert, Deposits of desert environments, Hamada deposits, Serir deposits, Desert lake and inland sebkha deposits, Wadi deposits, Aeolian sand deposits, Sand drifts and sand shadows, Gozes, Sand sheets, Sand dunes, Dust or loess deposits, Identification of the desert environment in ancient sediments

Lake environment: Clastic lake deposits, Distribution of sedimentary structures in the delta body.

Fluvial environment: Channel pattern, Fluvial environments and their deposits, Channel lag deposits, Point bar diposits, Channel bar and braided river deposits, General characteristices of gravelly braided streamdeposits, Deposits of suspended load rivers, natural levee deposits, crevasse-splay deposits, channel-fill deposits, flood plain deposits, flood basin deposits, alluvial fan deposits, debris flow deposits, water laid deposits, distribution of facies in a fan, humid alluvial fan.

Estuarine environment: Classification and hydrograph of estuaries, Sedimentation and bioturbation, Fjords.

Deltaic environment:the structure of a delta, Sub environments of delta,Development of repetitive lateral and vertical sequences in delta system, Deposits of the delta environment.

The coast: Definition and classification,Coastal sand, Beach dynamics and sediment transport, Washover fans, Backshore, Foreshore,Shoreface Vertical sequences of coastal sand.

The shelf: Hydrodynamic conditions on the continental shelf, Transition zone, Shelf sediments, Sand deposits on the continental shelf.

Coastal lagoons: Distribution of sediment sediment and sedimentary structures, Barrier Beach, Tidal channels, Gullies (tidal Creeks), Intertidal zone, Barren zone, Marsh, Salt pans.

Tidal flats: Physiography and morphology, Type of bedding in tidal flat sediments, Tidal channels, Surface structures, Horizontal and verticalsequences of tidal flat, Intertidal sandbars.

Continental margin, slope, and ocean basin: Major units of continental margins, Submarine canyons and fan valleys, Transport system in the continental shelf, margin and ocean basins, High density, high-velocity turbidity currents and turbidite deposits, Transport and deposition of sand, Transpot and deposition of sand-debris flow and pebbly mudstone deposits, Deposition in submarine canyonsand deep-sea fan regions, Ancient deep-sea fan and fan valley deposits, Low-velocity, low-density turbidity current, Contour currents and contourites, Large-scale gravity slide and slump deposits, Current marking and related sedimentary structures in deep-sea sediments, Bedding and bioturbation structures in the bottom.

Course Title: Sedimentology **Full Marks: 15**
Course No.: GEO 517 **Pass Marks: 06**
Nature of the course: Practicals **Year: First**

Course Contents:
Study of sedimentary grains and sediments. Study of sedimentary rocks. Megascopic and microscopic examinations. Textures and structures of sedimentary rocks. Grain size analyisis of consolidated and unconsolidated sediments. Shape analysis of sedimentary grains. Heavy mineral separation techniques, insoluble residue studies. Graphical methods of representing analytical data. Statistical representation of the results of various analyses. Primary sedimentary structures and penecontemporaneous deformation structures. Invironmental interpretations. Interpretation of paleocurrent and paleohydrology.

Textbooks:

1. Freidman G. M. and Sanders J. E. (1978): *Introduction to Sedimentology*, Wiley, New York
2. Reineck H. E. and Singh I. B. (1980): *Depositional Sedimentary Environments, 2nd edition*, Springer Verlag, 549 p.
3. Pettijohn F. J. (1984): *Sedimentary Rocks, 3rd edition*, CBS Delhi, 628 p.
4. Tucker M. E. (1991): *Sedimentary Petrology, An Introduction to the Origin of Sedimentary Rocks*, Blackwells Oxford, 260 p.
5. Lindholm R. C.(1991): *A Practical Approach to Sedimentology*, CBS Publishers and Distributors Delhi, 276p.

Reference Books:

1. Medilton, Blatt, et al. *Sedimentary Rocks*
2. Reading H. G. (1986): *Sedimentary Environment and Facies*, Blackwells Oxford, 615 p.
3. Collinson J. D. and Thompson D. B. (1994): *Sedimentary Structures*, CBS Delhi, 207 p.
4. Berner R. A. (1971): *Principles of Chemical Sedimentology*, McGraw Hill Inc., New York 240 p.
5. Tucker M. E. (1996): *Sedimentary Rocks in the Field*, John Weily & Sons, New York 153 p.
6. Tucker M. E. (editor) (1988): *Techniques in Sedimentology*, Blackwells Oxford, 408 p.
7. Blatt H. (1992): *Sedimentary Petrology*, Freeman, New York 514 p.
8. Allen J. R. L. (1985): *Principles of Physical Sedimentology*, Unwin-Hyman, London, 272 p.
9. Selly R. C. (1985): *Ancient Sedimentary Environments*, Chapman and Hall, New York 380 p.

Geomorphology

Course Title: Geomorphology
Course No.: GEO 512b
Nature of the course: Theory

Full Marks: 50
Pass Marks: 20
Year: First

Course Description: The course on geomorphology provides the students with the understanding of the earth's surface features (i.e., landscape) in relation to the external and internal processes. It also studies the processes responsible for the change of the earth's landscape.

General Objective: To give in-depth knowledge and understanding of the earth's landscape.

Specific Objective: To provide the students with in-depth knowledge and practical skills of

- Landforms and their classification,
- Factors affecting the formation of and changes in landforms, and
- Processes undergoing in the earth's crust, at the surface, in the hydrosphere, and atmosphere leading to the modifications of the landforms.

Course Contents:

Introduction

Approaches to geomorphology: Concepts, The geomorphological system, Geomorphic scale.

Morphologic evolutionary systems: The cycle of erosion, interruptions of the cycle of erosion, denudation chronology, criticisms of the cycle and alternative models, strategies for inferring landform evolution, equilibrium landforms, new evolutionary concepts.

Cascading process system: The solar energy cascade, The hydrological cycle, Denudation, Diastrophism, Diastrophism and erosion.

Igneous activity and landforms: Igneous activity in space and time, Intrusive constructional forms, Extrusive constructional forms, Igneous tectonism.

Structure and landforms: Horizontal and domed structures, Homoclinal structures, Folded structures, Faulted structures.

Lithology and landforms: Arenaceous landforms, Argillaceous landforms, Calcareous landforms, Igneous destructional landforms, Rock strength.

Geomorphic processes and landforms

Weathering: The earth-atmosphere interface, Processes of weathering, rates of weathering, The weathered mantle.

Mass movements: Significance, Gravity tectonics, Classification, Location of mass movement, Causes of mass movement, Mass movement and landform evolution.

Hillslopes: Introduction, Characteristic slopes, Classification of hillslopes, Origin of hillslopes, Hillslope erosion, The evolution of hillslopes.

Rivers: Significance, Open-channel hydraulics, Sediments transport, Hydrology, River morphology, Channel stability, Example o river metamorphosis, Rivers and valley morphology.
Drainage basins: The basin geomorphic unit, Morphometric analysis, Morphometric control, Drainage basin evolution, Drainage basin response.
Fluvial depositional landforms: Alluvial fans, Valley fills, Deltas.
Coastal geomorphology: Sea level, waves, and currents, Beach processes and profile, Shoreline processes and depositional forms, Erosional coasts, Sea-level variations, Organic coasts, Coastal management.
Aeolian processes and landforms: Aeolian environments, Aeolian sand movement, Wind abrasion, Aeolian bedforms, Coastal sand dunes, Loess, Snow drifting.
The glacier sedimentary system: Glaciers, Glacier ice, Glacier flow, Rock debris in glaciers, Processes affecting debris at the glacier sole, Erosion by glaciers, Deposition by glaciers, Landforms of glacial deposition, The glacier meltwater subsystem.

Climatic geomorphology
Morphogenetic landforms: Morphogenetic regions, Humid tropical landforms, Tropical wet-dry landforms, Arid and semi-arid landforms, Cold region landforms.
Geomorphological effects of former glacier expansion: Introduction, Direct erosional effects, Direct depositional effects, Indirect effects.
Climatic change and polygenetic landforms: Climatic change, The geomorphic effects of climatic change.

Textbooks:

1. Chorley R. J., Schumm S. A., and Sugden D. E. (1984): *Geomorphology*, Methuen, 605 p.

Reference Books:

1. Bloom A. L. (1992): *Geomorphology*, Prentice Hall of India, 532 p.
2. Embleton C. and King C. A. M. (1975): *Glacial Geomorphology*, Edward Arnold, 573 p.
3. Critchfield H. J. (1992): *General Climatology, 4th edition*, Prentice Hall of India, 453 p.
4. King A. C. M. (1976): *Landforms and Geomorphology*, Dowden, Hutchinson and Ross Inc., 404 p.

Introduction to Geophysics

Course Title: Introduction to Geophysics **Full Marks: 35**
Course No.: GEO 513a **Pass Marks: 14**
Nature of the course: Theory **Year: First**

General Objective: To give knowledge and understanding of geophysical methods applied in geology.
Specific Objective: To provide the students in-depth knowledge and practical skills of gravity, electrical, magnetic, and seismic methods of exploration.

Course Contents:
General Geophysics : The earth as a planet. The solar system. The dynamic earth. Gravity and the figure of the earth. The earth's size and shape. Gravitation. The earth's rotation. Newton's law of gravitational attraction. Gravitational potential and equipotential surfaces. The earth's figure and gravity. Gravity anomalies. Seismology and the internal structure of the earth. Introduction. Elasticity theory. Seismic waves. The seismograph. Earthquake seismology. Seismic wave propagation. Internal structure of the earth. Earth's age, thermal and electrical properties. The earth's heat, Geoelectricity. Geomagnetism and paleomagnetism. Historical introduction, The physics of magnetism, Magnetic surveying. Paleomagnetism. Geomagnetic polarity. Magnetic properties of rocks and minerals. Variations with time in the earth's magnetic field. Geomagnetic field and its elements. Geodynamics. Isostasy. Rheology. Plate dynamics.
Exploration Geophysics : General principles of Exploration Geophysics. Geophysics as a tool for determining geological structures and indirect mineral location. Major fields of geophysical exploration. Classification of methods of geophysical exploration. Significance and measurment of physical quantities involved. Arrangement of observation points with relative to geological objects. Geophysical anomaly, regional and local anomalies, factors controlling the anomaline. Factors giving rise to noise, qualitative and quantitive interpretations. Ambignities in interpretation. Integrated geophysical methods. Geological applications of geophysical methods, Regional geophysics, oil and gas geophysics, ore geophysics, ground water geophysics and engineering geophysics.
Gravity methods: Normal gravitational field. Determination of absolute gravity. Gravimeters. Techniques of gravity surveys. Data reduction. Gravity anomalies. Qualitative and quantitive interpretation. Application of gravity methods, regional geological and tectonic studies. Exploration for minerals, oil and gas, engineering problems.
Magnetic methods : Basic concepts and definitions. Working principles of various types of magnetometers. Magnetic surveying procedures. Data reduction. Qualitative and quantitive interpretations. Application of magnetic methods.
Eletrical methods : Eletrical properties of rock and minerals. Eletrical field caused by a point change. SP method. Resistivity methods (profiling and

sounding). Mise-a-la-masse method. Equipotential line method. IP method. Magnetotelluric and EM methods. Basic EM theory : amplitude and phase methods, VLF method; Turam and Slingram method; basic principles of magnetotelluric methods.

Seismic methods: Instruments used in seismic prospecting sources of seismic energy.

The seismic refraction method: Wave paths and time distance relations for horizontal layers. Continuous change of speed with depth. Refraction shooting across a fault. Dipping beds. Delay times. Refraction operation in the field. Refraction record. First and second events.

The seismic reflection method: Geometry of reflection paths for horizontal interfaces. Reflection from dipping interfaces. Determination of average velocity. Corrections used in reduction of reflection records. Multiple reflections. Meaning of interpretation.

Radioactivity methods.

Course Title: Introduction to Geophysics **Full Marks: 15**
Course No.: GEO 518a **Pass Marks: 06**
Nature of the course: Practicals **Year: First**

Course Contents:
Techniques of gravity surveys. Qualitative and quantitive interpretations. Application of gravity methods in the field.
Magnetic surveying procedures. Qualitative and quantitive interpretations. Application of magnetic methods.
SP method. Resistivity methods (profiling and sounding). Mise-a-la-masse method. .Equipotential line method. IP method. Magnetotelluric and EM methods.
The seismic refraction methods and reflection methods.

Textbooks:

1. Dobrin, M.B. and Savit, C.H., 1988. *Introduction to geophysical prospecting*. McGraw-Hill Book Company, 867 p.
2. Telford, W.M., Geldart, L.P., Sheriff, R.E. and Keys, D.A., 1976. *Applied Geophysics, 2nd edition*, Cambridge University Press, 860 p.
3. Dobrin M. B. (1981): *Introduction to Geophysical Prospecting*, Third Edition, McGraw Hill Inc., 630 p.
4. Lowrie W. (199.): *Fundamentals of Geophysics*

Reference Books:

1. Richter C. F. (1969): *Elementary Seismology*, S. Eurasia Publishing House Pvt. Ltd., 768 p.
2. Keller, G. V. and Frischknecht, F. C., 1966. *Electrical methods in geophysical prospecting*. Pergamon Press, 517 p.
3. Parasnis, D.S., 1997. *Principles of applied geophysics*. Chapman & Hall, 429 p.

Concepts of Mineralogy and Geochemistry

Course Title: Concepts of Mineralogy and Geochemistry **Full Marks: 35**
Course No.: GEO 513b **Pass Marks: 14**
Nature of the course: Theory **Year: First**

Course Description: It provides the concepts and methods of study, analysis, and interpretation of mineralogical composition and geochemical charactersistics of the earth.

General Objective: To give in-depth knowledge and understanding of mineralogy and geochemistry.
Specific Objective: To provide the students with in-depth knowledge and practical skills on modern techniques of

- mineral identification,
- mineral classification,
- mineral composition, and
- geochemical study and analysis of the rocks and minerals.

Course Contents:
Mineralogy: Internal symmetry in crystal., Review of space lattice and point group symmetry, Screw axes, Simple glide planes and combinations.
Space groups isogonal with monoaxial point groups, Polyaxial space groups of the first sort polyaxial and space groups of the second sort inverting glide planes.
A general symmetry of 230 space groups.
X-ray crystallography. X-ray diffractometer, Common metals and filters, Laue equations, Bragg equation and reflection indices, Calculation of cell dimensions, The reciprocal lattice, Identifying crystalline unknowns with the help of ASTM fills, Cell parameters -interaxial angles, all edges, and cell volumes,Systematic absences due to lattice, Impose conditions (Screw axes and glide planes).
Chemical mineralogy. Atomic and ionic radii, binding forces in crystals, co-ordination principle, radius ratio, unit cell content, recalculation of analysis, compositional variation in minerals, graphical representation of compostional variation, exsolution.
Optical Mineralogy. Principle and application of Becke method, uniaxial and biaxial crystals, uniaxial and biaxial indicatrices, Uniaxial and biaxial crystals between crossed polar interference, Accessory plates and Berek compensator, Uniaxial and biaxial crystals in the convergent light, determination of optic signs of uniaxial and biaxial crystals. Dispersion of optic axis, optic angle and apparent optic angle, sign of elognation, absorption and diachroism. Introduction to universal stage.
Crystal chemistry of mineral. General review, Crystallochemical formulas of minerals determination and calculation of unit cell content, Crystallochemical classification of minerals.

Mineral systematics. Crystal structure, Diagnostic properties, P-T stability paragenesis and alteration of common rock forming mineral groups.
Silicates. Olivine, Melilites, Pyroxenes, Amphibole, Micas, Feldspars, Quartz and its polymorphs, Garnets, Leucite, Nephaline and clay minerals.
Others. Spinel, Calcite, Dolomite.

Geochemistry: Introduction. Historical development and present status. The earth in relation to the universe. Composition of the univers: sun, planets, and meteorites. Abundance of elements in the earth and universe. Origin of elements. The structure and composition of the earth. Primary differentiation of the elements. Pregeological history of the earth.

Structure of the atoms, ions, and molecules. Chemical bonding. Structure of crystalline material. Principles of thermodynamics and applicaiton to petrology. Chemical potential, equilibrium constants. Thermodynamicsl of chemical reaction.Nature of ideal solution. Geochemistry of magmatism, sedimentary formations, metamorphism, endogenetic ore formation, atmosphere, hydrosphere, biosphere, and hypergenesis. Geochemistry of isotopes. Geochemical evolution of the earth. Geochemical cycles.

Course Title: Concepts of Mineralogy and Geochemistry **Full Marks: 15**
Course No.: GEO 518b **Pass Marks: 06**
Nature of the course: Practicals **Year: First**

Course Contents:

Mineralogy: Study of space groups, Sample preparation and XRD pattern, Indexing an XRD pattern, Calculation of 2θ and d values, Calculation of cell parameters of a cubic and an orthorhombic crystal., Calculation of crystallochemical formula of several minerals

Geochemistry: Trace elements analysis of igneous rocks and their interpretation, REE analysis in crystal rocks

Analysis of groundwater, river water, ocean water, Analysis of coexiating minerals in rocks and their geothermoberometry

Text Books:

1. Blackburn W. H. and William H. D. (1999): *Principles of Mineralogy*, Wm. C. Brown Publishers, 413 p.
2. Mason B. and Moore C. B. (1982): *Principles of Geochemistry*, Mohinder Singh Sejwal, 350 p.

Reference Books:

Klein C. and Hurlbut. Jr. (1985): *Manual of Mineralogy*, John Weily & Sons, 596 p.

Krauskopf K. B. and Bird D. K. (1995): *Introduction to Geochemistry, 3rd edition*, McGraw Hill Inc., 647 p.

Course Title: Structural Geology | **Full Marks: 35**
Course No.: GEO 514a | **Pass Marks: 14**
Nature of the course: Theory | **Year: First**

Course Description: Structural geology deals with the architecture of the earth's crust and its componental parts. The course also provides the skills and techniques of study, analysis, and interpretation of the geological structures and their development in space and time.

General Objective: To give in-depth knowledge and understanding of the structure of the earth's crust and its various components.

Specific Objective: To provide the students with in-depth knowledge and practical skills for the study, analysis, and interpretation of:

- folds,
- faults,
- joints,
- foliation, and
- lineation.

This course also provides the concepts of stress and strain.

Course Contents:

Introduction: Concept, approach, and scope of structural geology. Primary and secondary structures.

Primary Structures: Primary sedimentary structures and their significance in structural geology. Diapirs, and salt domes, their classification and origin. Collapse structures. Structure of igneous rocks.

Stereographic projection: Introduction. Plotting a line and a plane. Rotation of lines and planes. Graphical treatment of the fabric data. Plotting and analysis of various structural elements. Uses and limitation of pi and beta diagrams. Concept of preferred orientation. Fabric and its symmetry in tectonites and non tectonites and structural geological mapping.

Stress: Stress at a point. Stress on a plane. Stress ellipse. Principal planes of stress and axial cross section. Mohr circle. Types of stresses and Mohr circle configurations for them. Stress in two and three dimensions. Mohr diagram. Strain in two dimensions. Progressive deformation. Calculation of finite strain in two dimensions. Rheology, stress-strain relation of elastics, viscous and viscoelastic materials. Theory of brittle and semibrittle rock behaviors. Behavior of crystal structure under stress.

Strain: Definitions. Displacement vector. Displacement field. Displacement gradient. Homogeneous and inhomogeneous deformations. Strain indicators. Strain ellipse and reciprocal strain ellipse. Lagrangian and Eulerian specifications. Homogeneous deformation of straight line. Circle and ellipse (theory). Changes in lengths and orientation of lines in different zones with strain ellipse and corresponding geological structures. Types of homogeneous strain ellipsoids and effect of volume change on deformation. Determination of

finite strains from originally spherical and ellipsoidal markers. Behavior of rocks with respect to stress and strain.

Folds: Fold morphology. Classification of folds. Fold mechanism: Single layers and multi layers. Small-scale structures in folds and their interpretation. Distribution of strain in folds. Superposed folding. Criteria of recognition of folds.

Geometry and mechanism of folding. Parameters of defining single folded surface. Different classifications of folds. Buckling. States of strain within and outside buckled layers and field evidences of buckling. Shear folds and mechanism of similar folding. States of strain in a similar folds. Modification of buckle and shear folds. Concepts of fold vergence.

Foliations: Definition. Morphology of different types of axial plane foliations. Transposed foliations and other metamorphic foliations. Orientation of foliation within strain ellipsoid.

Lineations: Definition. Classification. Their relation with respect to strain ellipsoid. Significance of lineation in tectonic history of tectonics. Relationship between planner and linear elements.

Structural analysis: Principles of structural analysis. Phases of structural analysis. Scale homogeneity and symmetry. Structural analysis of areas of one, two, and three phases of deformation. Interference structures of different scales and their origin.

Joints, fauls and shear zones: Joints. Classification and significance. Faults. Normal, thrusts and strike slip faults. Their classification and characters. Mechanism of faulting with reference to stress and strain ellipsoids. Classification and geometry of different types of shear zones. Strain variations within shear zone. Origin and significance of different types of minor structures within shear zones. Sense of movement and its determination in shear zones. ,Geometry of folds and thrust belts

Principles of Tectonics: Orogeny and epiorogeny. Thrusts and nappes. Schuppen and duplex. Geosynclines and continental margins. Continental drift. Introduction to plate tectonics. Sea floor spreading. Mid-oceanic ridges. Paleomagnetism. Seismic zones. Transform faults and triple junctions. Island arcs. Causes of orogeny and global tectonics. Orogenic belts with special references to Himalaya.

Course Title: Structural Geology
Course No.: GEO 519
Nature of the course: Practical

Full Marks: 15
Pass Marks: 06
Year: First

Practicals :

Contours and topography. Relationship between contours and contacts. Rule of V's. Recongnition of inliers, outliers, windows, klippen.

Study of structural features and stratigraphic sequence of the given geological maps.

Study of geological maps and preparation of geological cross-sections of horizontal, inclined, vertical, and folded beds. Study of geological maps with unconformity, faults, and dykes.

Apparent and true thickness of beds. Determination of through of faults.

Stereographic projection techniques. Plotting a line and a plane on the stereo net. Ple' to the plane. Pole net and its use. Trend, plunge, and pitch of a line and their representation on the stereo net. Dip and strike of a plane and their representation on the stereo net. Apparent dip and true dip. Line of intersection of two planes. Pi and beta diagrams.

Rotation of structural data by using the stereo net. Contouring techniques.

Three - point - problems. Bore hole data analysis and interpretation. Depth and distance calculations. True and apparent dips. Calculation of vertical and horizontal through.

Geometrical and stereographic techniques for he determination of net slip, dip slip, and strike slip along the fault planes. Busk construction of parallel folds. Construction of similar folds. Dip isogon analysis of folds. Construction of profiles of plunging cylindrical folds.

Text Books:

1. Hobbs B. E., means W. D., and Williams P. F. (1976) : *An Outline of Structural Geology*, John Wiley and Sons, 571 p.
2. McClay K. R. (1987) : *The Mapping of Geological Structures*, John Wiley and Sons Inc., 161 p.
3. Ragan D. M. (1985) : *Structural Geology, An Introduction to Geometrical Techniques, 3rd edition*, John Wiley and Sons Inc., 393 p.

References :

1. Spencer (1977) : *Introduction to the Structure of the Earth*, McGraw Hill Kogakusha, 640 p.
2. Le Pichon X., Francheteau J., and Bonnin J. (1976) : *Plate Tectonics*, Elsevier, Second Edition, 311 p.
3. Bayly B. (1991) : *Mechanics in Structural Geology*, Springer - Verlag, 253 p.
4. Johnson A. M. (1977) : *Styles of Folding*, Elsevier Scientific Publishing Company, 406 p.
5. Ramsay J. G. (1967) : *Folding and Fracturing of Rocks*, McGraw Hill Inc., 568 p.

Geology of Himalayas

Course Title: Geology of Himalayas **Full Marks: 50**
Course No.: GEO 514b **Pass Marks: 20**
Nature of the course: Theory **Year: First**

Course Description: Himalayan geology covers the tectonic, structural, stratigraphic, igneous, metamorphic, and sedientary geological as well as palaeontological and economic geological aspects of the Himalayas.

General Objective: To give in-depth knowledge and understanding of the Himalayan geology.

Specific Objective: To provide the students in-depth knowledge of

- Various stratigraphic subdivisions of the Himalaya,
- Tectonic and structural setup of the Himalaya and its relation with the adjacent regions, and
- Comparison, correlation, and age relations of various rock units.

Course Contents:

Broader framework of the Himalays. Its relation to other mountain chains of the region. Introduction to the geology of Peninsular India with special reference to Delhis, Vindhiyans, and Gondwanas. Brief account of the Salt Range, Punjab, Kumaon, Nepal, Sikkim, and Bhutan Himalaya. Precambrian succession of Higher and Lesser Himalaya, classification and correlation, reference sections from Nepal and adjacent countries. Paleozoic successions of Tethys (Tibetan) and Lesser Himalaya, subdivision and correlation, reference sections from Nepal and adjacent countries. Mesozoic succession of Tethys and Lesser Himalaya of Nepal and adjacent countries, subdivisions and correlation of stratigraphic units of Mesozoic earthem, reference sections. Tertiary, Tertiary successions of Lesser and Sub-Himalaya zones of Nepal and adjacent countries, subdivision and correlation, reference sections. Quaternary succession of intermountain basins of Lesser and Higher Himalaya, Dun valleys of Sub-Himalaya zone and Indogangatic plains of Nepal and India, subdivisions and correlation.

Tectonic setup of the Himalaya. Diastrophism. Collision and suture zone. Metamorphism. Himalayan Granites.

Textbooks:

1. Gansser A. (1964): *Geology of the Himalayas*, John Wiley & Sons Inc.
2. Valdiya K. S. (1984): *Aspects of Tectonics Focus on South Central Asia*, Tata-McGrawHill, 319.
3. Valdiya K. S. (1998): *Dynamic Himalaya*, Universities Press,New Delhi, 178 p.

Reference Books:

1. Yin A. and Harrison T. M. (eds.) (1996): *The Tectonic Evolution of Asia*, Cambridge University Press, 666 p.

2. Shakleton, R. M., Dewey J. F., and Windley B. F. (eds.) (1988): *Tectonic Evolution of Himalayas and Tibet*, Cambridge University Press, 325 p.
3. Valdiya K. S. (1980): *Geology of the Kumaon Lesser Himalaya*, Wadia Institute of Himalayan Geology, 291p.

Project Management

Course Title: Project Management | **Full Marks: 35**
Course No.: GEO 515a | **Pass Marks: 14**
Nature of the course: Theory | **Year: First**

Course Description: Project Management deals with the methods and techniques of handling the projects in a scientific way. It saves time and cost (money) and enhances the performance.

General Objective: To give the knowledge and understanding of the project management skills and techniques.

Specific Objective: To provide the students with the understanding of

- Project evaluation and selection,
- Organising and staffing,
- Project planning, and
- Project implementation.

Course Contents:

Introduction : Good project management saves time and cost (money) and enhances the performance. Objective of the course: understanding concept and making project management work in practice.

Overview; Understanding project management. Introduction: projects in contemporary organisation. The definition of a *Project*. Why project management? The project life cycle.

Project Initiation : Project evaluation and selection: Criteria for project selection. The nature of project selection. Types of project selection. Project risk analysis. Sources of information for project evaluation-selection. Project proposals.

Organising and staffing; The project office and the team. The staffing environment. The project manager: his role and responsibilities.

Essence of a project manager (skill requirements). Selecting the project manager.

The project organisation. Choosing an organisational form leadership and team building in the project environment.

Project Planning. The project manager as a planning agent. Project planning and its elements. Initial project condition and systems integration. The project action plan and milestone schedules. The work breakdown structures and linear responsibility charts. Interface management. Why do plan fail? Project critical success factors.

Nagotiation and conflict resolution: Understanding conflicts in the projects. Management pitfalls. Conflict and the project life cycle. The management of conflicts. Negotiation for conflict resolution. Requirements and principles of negotiation.

Project Implementation : Budgeting: Budget and budgeting methods. Pricing and cost estimation. Estimating pitfalls. The low bidder dilemma.

Scheduling: Introduction. Network techniques: PERT an CPM. Gant Charts. Other conventional presentation techniques. Extensions and applications.
Resource allocation: Critical path method. The resource allocation problem. Resource loading. Resource levelling. Constrained resource scheduling. Multiproject scheduling and resource allocation.
Project Monitoring and Management Information Systems (PMIS): Understanding planning, monitoring, and controlling cycle. Information needs and reporting. PMIS requirements.
Project Control: Project control and its purpose. Types of control process. Designs of control systems. Control of creative projects.
Project Termination : Project evaluation and auditing: Project evaluation and its purpose. The project audit: depth and timing. Application of the audit report. The project audit life cycle. Essentials of audit/evaluation.
Project termination: Types of project termination. The termination process. Project final report.

Project Management

Course Title: Project Management **Full Marks: 15**
Course No.: GEO 520 **Pass Marks: 06**
Nature of the course: Project work **Year: First**

Project Work: Project work on one of the ongoing projects or institutions.

Textbooks:

1. Meredith J. and Mantel S. J. (1989): *Project Management - A Managerial Approach.*
2. Krezner H. (1987): *Project Management - A System Approach in Planning, Scheduling, and Controlling*.

Field Work

Course Title: Field Work | **Full Marks: 50**
Course No.: GEO 515b | **Pass Marks: 20**
Nature of the course:Practical | **Year: Second**

Course Description: Field work is carried out to provide the field knowledge of rocks, their texture, structure and techniques and skills of observation, data recording, sampling, description, analysis, interpretation and mapping of rocks and their structures in the field.

General Objective: To give the knowledge, techniques and skill of geological mapping in the field.

Specific Objective: To provide the students with the techniques of

- Describing rock outcrop.
- Mapping of rock outcrop.
- interpretation of rocks texture and structure paleocurrent, sedimentary structure, folds and faults. and .
- Preparation of geological maps, stratigraphic columns and geological cross-sections.

Course Contents:

Location: The fieldwork will be carried out in the Dang, Sallyan, Piuthan, Palpa, Syangya and Kaski disrricts. The location may vary depending upon the criteria set by the Department

Introduction: Study of topographical and geological maps of the area, identification of main lithological, stratigraphic and structural features of the area and study of contacts of various rock units.

Mapping: Preperation of root maps and colunmar section of the important units. Mapping of lithological boundaries, tectonic contacts and other stryctural features (folds, faults, joints, foliation,bedding, etc.). Preperation of the geological maps in 1:50,000 and 1:25,000 scales.

Interpretation: Inerpretation of the data on the basis of measured altitudes of beds and foliation. Use of stereographic projection in paleocurrent analysis and contouring the field data. Interpretation of environments of deposition of sedimentary rocks. Interpretation of geological structures and preperation of geological cross-section.

Field report: The field report includes chapter on regional setting, previous works, lothology, stratigraphy and environment of deposition, structural interpretation of the area and geological maps and cross-sections. Apart from the report, the students will collect relivant rocks and fossil samples. The students prepare drawings, maps, and field note books contanning all the relevant informations. They will also prepare thin sections and analyse the data in the laboratory.

Textbooks:

1. Thrope R. S. and Brown G. C. (1995): *The Field Description of Igneous Rocks*, John Weiley & Sons, 154 p.
2. Barnes J. W. (1981) : *Basic Geological Mapping*, Geological Society of London Handbook Series, No. 1 Open University Press.
3. Tucker M. (1982) : *The Field Description of Sedimentation Rocks*, Geological Society of London Handbook Series, No., Open University Press.
4. Fry, N. (1984) : *The Field Description of Metamorphic Rocks*, Geological Society of London Handbook Series, No. 3 Open University Press.
5. McClay K. R. (1987): *The Mapping of Geological Structures*, John Wiley & Sons Inc., 161 p.

Reference Books:

1. Gansser A. (1964): *Geology of the Himalayas*, John Wiley & Sons Inc.
2. Journal of Nepal Geological Society (various issues).
3. Bulletien of Department of Geology. (various issues).

Table 3a: Second year
Stream: Natural Resources Studies

Theory

Course No.	Courses Title	Full Marks	Pass Marks
GEO. 611	Mineral Resources	70	28
GEO. 612a	Advanced Techniques of Mineralogy	35	14
GEO. 612b	Geochemical exploration and environmental geochemistry	35	20
GEO. 613a	Mineral Economics and Agricultural Geology	50	14
GEO. 613b	Mining Geology and Underground Excavations	50	14
GEO. 614a	Photogeology, Geoinformatics and Mapping Techniques	35	14
GEO. 614b	Fieldwork	50	20

Practical

Course No.	Courses Title	Full Marks	Pass Marks
GEO. 615	Mineral Resources	30	12
GEO. 616a	Advanced Techniques of Mineralogy	15	06
GEO. 616b	Geochemical exploration and environmental geochemistry	15	06
GEO. 617	Photogeology and Geoinformatics	15	06
GEO. 618	Dissertation	100	40

Mineral Resources

Course Title: Mineral Resources **Full Marks: 70**
Course No.: GEO 611 **Pass Marks: 28**
Nature of the course: Theory **Year: Second**

Course Description: Mineral Resources deals with the modern methods of investigation of minerals

General Objective: To give in-depth knowledge and understanding of the mineral resources.

Specific Objective: To provide the students with in-depth knowledge and practical skills for the study, analysis, and interpretation of, Occurrence and types of mineral deposits, Industrial rocks and minerals and Water as the mineral resource

Course Contents:

Nature and morphology of the principal types of ore deposits. Textures and structures of ore and gangue minerals. Fluid inclusions. Wall rock alteration. Major theories of ore genesis. Geothermometry, Geobarometry, paragenetic sequence, zoning and dating of ore deposites. Classification of ore deposits. Diamond deposits in kimberlites and lamproites. Carbonatite - alkaline igneous ore environment. Pegmatitic environment and gem stones. Orthomagmatic deposits of chromium, platinum, titanium, and iron associated with basic and ultrabasic rocks. Orthomagmatic cupper-nickel-iron (-platinoid) deposits associated with basic and ultrabasic rocks. Greisen deposits. Skarn environment. Disseminated and stockwork deposits associated with plutonic intrusives. Stratiform sulphide, oxide, and sulphate deposits of sedimentary and volcanic environments. Stratabound deposits. Vein association and some other hydrothermal deposits. Sedimentary deposits. Residual deposits and supergene enrichment. Metamorphism of ore deposits.

Industrial rocks and minerals: Aggregates and construction materials. Clays, evaporites, graphites, limestone and dolomite, magnesite, olivine, phosphates, abbrasives, sulphur, fluorspar, asbestos, nepheline syenite, slate, wollastonite.

Origin of water: Formation of the ocean floor and continental land masses. Origin of the earth's hydrosphere. Evolution of the earth's atmosphere.

Formation of aquifer systems: alluvial aquifers, sedimentary, metamorphic, and igneous rock aquifers.

Weather patterns and the hydrological cycle. Coriolis effect. Causes of precipitation. Effect of precipitation on groundwater. Hydrological cycle. Pathways of water.

Occurrence and movement of groundwater: Types of subsurface water, Energy contained in groundwater, Aquifer functions, Flow nets, and Groundwater flow velocities.

Groundwater chemistry: Origin of the chemical constituents of groundwater, Units of measure, Important properties of water, Groundwater constituents, Water quality, Methods to present water quality data, Importance of water chemistry.

Course Title: Mineral Resources **Full Marks: 30**
Course No.: GEO 615 **Pass Marks: 12**
Nature of the course: Practicals **Year: Second**

Course Contents:

- Study of rock-ore/mineral associations examples
  Dunite-peridotite-pyroxenite-chlorite-surpentenite-chrysotile-asbestos
  Norite-gabbro-dolerite-basalt-titaniferous magnetite-ilmenite-chalcopyrite-pyrrhotite-pentandite
  Pegmatite-cassiterite-wolframite-scheelite-beryl-appatite-mica etc.
- Calculation of reserves
  Polishing of ores
  Study of polished sections of ores in reflected light- mineralogy, textures, paragenesis
  Estimation of reflectivity, microhardness
- Specification and industrial properties of rocks, mineral aggragates, ores
  Study of fluid inclusions in minerals with genesis of mineral deposits
- Study of the following minerals:
  Pyrite, Galena, Sphalerite, covellite, chalcopyrite, chalcosite, pyrrhotite, magnetite, haematite, wolframite, chromite, ilmenite, sheelite, arsenopyrite, marcasite, malchite, azurite, native copper, silver, gold, diamond, cassiterite, rutile, ilmenite, pentlandite, beryl, apatite, spadumene, graphite, tourmaline, uraninite, and related minerals.

Textbooks:

1. Evans A. M. (1993): *Ore Geology and Industrial Minerals,* Blackewll Scientific Publications,
2. Smirnov V. I. (1989): *Geology of Mineral Deposits*, Namechand and Brothers, 520 p.

Reference Books:

1. Jensen and Bateman (1981): *Economic Mineral Deposits*, John Wiley & Sons Inc., New York
2. Hutchinson C. S. (editor) (1988): *Geology of Tin Deposits in Asia and the Pacific*, Springer Verlag, 718 p.
3. Craig and Vaughan (1981): *Ore Microscopy and Ore Petrography*, John Wiley &Sons Inc., New York

Advanced Techniques of Mineralogy

Course Title: Advanced Techniques of Mineralogy **Full Marks: 35**
Course No.: GEO 612a **Pass Marks: 14**
Nature of the course: Theory **Year: Second**

Course Description: Advanced Techniques of Mineralogy deals with the modern methods of investigation of minerals using various tools such as XRD, XRF, DTA, EPMA, and LPA.

General Objective: To give in-depth knowledge and understanding of the modern methods of mineral investigation.
Specific Objective: To provide the students with in-depth knowledge and practical skills for the study, analysis, and interpretation by using:

- Polarising microscope,
- XRF and XRD,
- DTA,
- EPMA, and
- LPA.

Course Contents:
Mineral separation : Introduction. Preparation of Material. Separation by gravity. Magnetic separation. Electrostatic, high tension, and dielectric methods. Miscellaneous methods.
Microscopy : The polarising microscope. Refracted and reflected lights. Conoscopy.
Preparation of thin sections and polished sections. Identification of minerals by optical methods.
X-Ray Fluorescence Spectrometry (XRF) : Introduction. The nature and production of X-rays. Qualitative and quantitative analysis. Sample preparation. Trace element analysis.
X-Ray Defraction : Introduction. The X-ray beam. Powder method. Mineral identification. Indexing. Powder patterns and the determination of cell parameters. X-ray defraction intensities.Single crystal X-ray defraction. Examples of application of X-ray defraction methods.
Electron Probe Microanalysis : Introduction. Instrumentation. Specimen preparation. Quantitative analysis. Calculation of matrix correction factors. Processing of data from energy dispersive spectrometres. Fundamental limitations.
Atomic Absorption Spectroscopy : Introduction. Method. Interferences. Techniques. Sensitivity.
Infrared Spectroscopy : Introduction. Experimental Methods. Spectral data for minerals. Selected application to geological samples and processes.
Thermal Techniques : Introduction. Differential Thermal Analysis (DTA). Thermogravimetry (TG). Subsidiary techniques related to DTA and TG. Other techniques.
Flame Photometry : Introduction. Sample preparation. Qualitative analysis.

Radiographic Techniques : Introduction. Alpha particle autoradiography. Beta particle autoradiography. Fission track radiography.

Fluid Inclusion Analysis : Introduction. Methods. Thermometry. Cryometry. Decripitation. Determination of chemical composition.

Laser Probe Analysis : Introduction. Methods. Principles of laser microanalyser. Examples of mineral investiations.

Density Determination : Introdution. Methods of determining density.

Course Title: Advanced Techniques of Mineralogy **Full Marks: 15**
Course No.: GEO 616a **Pass Marks: 06**
Nature of the course: Practicals **Year: Second**

Course Contents:

- Microscopic Study
- DTA Study
- XRF and XRD study
- Mineral Separation
- Density Determination

Text Books:

1. Zussman J. (editor) (1977): *Physical Methods in Determinative Mineralogy,* Academic Press, 720 p.
2. Smirnov, V. I. (1975): *Laboratory Methods of Investigation of Minerals, Ores, and Rocks (in Russian*), Moscow University, 251 p.

Reference Books:

1. Hutchinson (1974): *Laboratory Methods in Petrography* ,John Wiley &Sons Inc., New York
2. Craig and Vaughan (19..): *Ore Microscopy and Ore Petrography*, John Wiley &Sons Inc., New York
3. Blackburn W. H. and William H. D. (1999): *Principles of Mineralogy*, Wm. C. Brown Publishers, 413 p.

Geochemical Exploration and Environmental Geochemistry

Course Title: Geochemical Exploration and Environmental Geochemistry **Full Marks: 35**
Pass Marks: 14
Course No.: GEO 612b **Year: Second**
Nature of the course: Theory

Course Description: Geochemical Exploration and Environmental Geochemistry gives necessary background material for geochemical exploration and preservation of environment.

General Objective: To give in-depth knowledge and practical skills of of the modern methods and techniques of geochemical exploration and environmental geochemistry.

Specific Objective: To provide the students with in-depth knowledge of:

- Geochemical exploration,
- Geochemistry of lanscape, and
- Environmental geochemistry.

Course Contents:

Geochemical Exploration: Introduction. History. Types of survey.
The primary environment: Distribution of elements in igneous rocks and minerals. Primary halos and primary dispersion. Pathfinders. Geochemical provinces. Geochemical associations.
The secondary environment: Chemical weathering. Physical weathering. Environmental factors affecting weathering. Soi. Application of pH and Eh. Adsorption. Mobility in the Secondary Environment. Water, groundwater, river water, lake water and sediments.
Some basic principles: Contamination. Orientatin surveys. False anomalies. Interpretation of geochemical data.
Field methods: Stream studies. Soils. Rocks. Water and Lake sediments.
Analytical Methods: Introduction. General Principles. Preparation of samples for analysis. Atomic absorption spectrometry. Colorimetry. Emission spectrography. X-ray fluorescence and other methods. Mobile laboratories.
Primary Dispersion: Introduction. Primary dispersion on a regional and local scales. Detailed patterns. Primary dispersion of mercury, helium, and related elements. Trace element content of minerals. Fluid inclusions. Isotope methods.
Secondary dispersion: Introduction. Displaced anomalies. Physical form an classification of secondary dispersion patterns. Mechanical dispersion. Dispersion patterns detected by partial extraction techniques. Geothermal patterns.
Regional and Detailed Surveys: Introduction. Location of geochemical provinces. Sediment collection. Detailed surveys.
Vegetation surveys: Introduction. Geobotany. Biogeochemistry.
Statistical Treatment of Geochemical Data: Introduction. Background values. Regional values. Correlation between elements. Classification of samples. Survey sampling. Anomaly detection.

Geochemistry of landscape: Geochemical role of living matter Formation of living matter,Decomposition of organic matter,Biologic cycle of chemical elements,Living matter in geological history.

Geochemical parameters of elements which condition their physical and chemical migration

Chemical bonds and crystal lattices of minerals, Valence, Dimensions of ions and atoms, Isomorpism, Ionic potential, Solubility.

Law of mass action in geochemistry: Dissociation constant and pH of water, Dissociation constants of acids, Complex ions, Undissociated molecules, Solubility product, Ionization power of natural waters, Concentration of elements in natural waters and its significance to the formation of minerals.

Analysis of energy involved in supergene migration

Chemical affinity, Oxidation-reduction reactions, Electrochemical leaching of sulfide ores, Stability ranges of minerals and chemical compounds, Le Chatelier principle, Fersman's geoenergetic theory, Principole of retardation of reactions.

Migration of colloids ,Occurrence of colloids in the supergene zone, Migration of subtances in the colloidal state, Sorption, Principal groups of colliodal minerals.

Occurrence of chemical elements in the supergene zone

Natural media of the supergene zone

Soil, Weathered crust, Surface and groundwaters, Geomical landscapes, Water-bearing strata of the catagenetic subzone, Weathering and cementation, Epigenetic zoning.

Factors in the development of media in the supergene zone

Climate, Zoning, Geologic structure.

Classification of the epigenetic processes operating in the supergene zone

Typomorphic elements, Aeolean and aqueous migrants, Intensity of aqueous migration of chemical elements, Classification of the supergene of processes.

Epigenetic processes of oxidation

The sulfatic processes, acid processes, The neutral carbonateic process, The chlor-sulfatic process, The soda process.

The Gley processes of reduction in epigenesis.

Epigenetic processes in reducing, sulfadic envirnments

The sulfato-sulfidic process, The oxysalt-sulfidic process, The soda-hydrogen sulfide process.

Geochemical barriers

The principal types of geochemical barriers, Epigenetic concentration of elements during cementation.

Development of epigenetic processes through geologic history

Environmental Geochemistry: Introduction ,Case historys, analysis and comparison, Geology, policy, and planning.

Soils, resources and problems

Soils, Soils as resources, Wind erosion, Erosion by moving water, Prediction and controlling erosion, Soil erosion and landuse decisions, Problems.

Water resources

Introduction, The hydrological cycle, Measurements employed in hydrology, Water use, Case histories, Groundwater, Water law and water policy.

Hazards and risks

Introduction, Identification and description of hazard, The evalution of risks, Adjustment to hazards.

Soil and water contamination

Introduction, Contaminations, Assessment of contamination, Sources of contamination, Process of contamination, Control and restoration changing, Attitudes towards contamination, Laws and predices

Medical geology.

Course Title: Geochemical Exploration and Environmental Geochemistry **Full Marks: 15**
Course No.: GEO 616b **Pass Marks: 06**
Nature of the course: Practical **Year: Second**

Course Contents:

Practicals :

Geochemical data and anomaly analysis in relation with mineral exploration. Exploration and drilling project preparation. Preparation of samples for analysis. Atomic absorption spectrometry. Colorimetry. Emission spectrography. X-ray fluorescence and other methods. Primary dispersion on a regional and local scales. Detailed patterns. Primary dispersion of mercury, helium, and related elements. Trace element content of minerals.

Physical from and classification of secondary dispersion patterns. Mechanical dispersion. Dispersion patterns detected by partial extraction techniques. Geothermal patterns.

Geobotany. Biogeochemistry.

Statistical Treatment of Geochemical Data : Introduction. Background values. Regional values. Correlation between elements. Classification of samples. Survey sampling. Anomaly detection.

Textbooks:

1. Levinson A. A. (1980): *Introduction to Exploration Geochemistry*, Applied Publishing Limited, 924 p.
2. Hawkes H. E. and Webb J. S. (1980): *Geochemistry in Mineral Exploration, Second Edition*, Harper and Row,
3. Perelman (1978.): *Geochemistry of Landscapes*Nedra, Muscow, 278p
4. Perelman A. I. (1967): *Geochemistry of Epigenesis*, Plenum Press, 266 p.
5. Soloviov A. P. (1987): *Geochemical Prospecting*, Mir Publishers, 287 p.

Reference Books:

1. Craig and Vaughan (1981): *Ore Microscopy and Ore Petrography*, John Wiley &Sons Inc., New York
2. Rowe, W. D. (1977) *An Anatomy of Risk*, John Wiley &Sons Inc., New York

Mineral Economics and Agricultural Geology

Course Title: Mineral Economics and Agricultural Geology
Course No.: GEO 613a
Nature of the course: Theory

Full Marks: 50
Pass Marks: 20
Year: Second

Course Description: Mineral economics provieds the information on the minerals, their grades, tenors, and reserves whereas agricultural geology dealis with the geological method applied in the agriculture.

General Objective: To give in-depth knowledge and understanding of mineral economics and application of geology in the agriculture.
Specific Objective: To provide the students with the information for the study, analysis, and interpretation of;

- Important ore and industrial minerals,
- Tenor, grade, and reserves of minerals,
- Soil geology,
- Fertilisers, and
- Management of land.

Course Contents:

Mineral Economics : Mineral Economics and its concept. Importance of ore and industrial minerals. Tenor, grade and specification. Strategic, critical, and essential minerals. Pecularities inherent in mineral industry. Conservation and substitution. Future sources of mineral supply. National mineral policy. Mineral taxation and incentive measures. Important factors in the economic recovery of minerals. Commodity prices - the market mechanism. The role of the firm.

Agricultural Geology : Soil Geology: Definition of soil. Its relationship with rock, water and vegetation. Stages, degrees of development, types and kinds of soil. Soil series. Types of phases.

Soil morphology. Chemical and physical constituents of soils. Total and available mineral bearing nutrients, ph, Eh, cation exchange relations. Development of soil profile. Taxonomy and classification. Orders sub-orders, great groups, family, and series.

Soil problems, genesis, nature, estimation and mapping of salite and alkaline soils, their characteristics and distribution.

Soil erosion, agencies influencing erosion. Wind, water, and gravity. Remedial measures to control hazards - engineering and agronomic. Soil conservation: problems, methods, and practices.

Classification of soils of Nepal and adjacent areas.

Clay mineralogy and geochemistry: Brief outline of primary minerals, their breakdown and formation of clay and other minerals. Physical proportions, chemical compositions, crystallography, structure and use of important clay minerals. Techniques of clay mineral identification. Diagenesis of clay minerals

and reconstruction of environments. Significance of clay minerals in soil classification.

Mineral fertiliser: Geology, sources, uses, production, distribution, resources, occurrence, and origin. Extraction an preparation of chief fertiliser minerals. Potash, mitrates, phosphates, gypsum, lime, sulphur, and minor fertiliser minerals, green sand, magnesite, dolomite, borax, and epsomite.

Land management: Development of migration facilities in relation to types of landscape, reclammation of land, use of relative data in the development of the area.

Textbooks:

1. Sinha R. K. and Sharma N. L. (197.): *Mineral Economics*, Oxford and IBH Publishing Company,
2. Chatarjee k. k. (1993): *Mineral Economics*, Wiley Estern Limited, New Delhi

Mining Geology and Underground Excavations

Course Title: Mining Geology and Underground Excavations **Full Marks: 50**
Pass Marks: 20
Course No.: GEO 613b **Year: Second**
Nature of the course: Theory

Course Description: Mining geology and Underground Excavations deal with the geological skills and knowledge for the study of mines and undergroud openings.

General Objective: To give in-depth knowledge and understanding of the modern methods of mining and underground excavations.
Specific Objective: To provide the students with in-depth knowledge and practical skills of:

- Techniques for driving mine openings,
- Technical and economic characteristics of mines and underground excavations, and
- Organisation and mechanisation of underground excavations.

Course Contents:
General Information on MineOpenings : Appraisal of exploration data for exploratory mining.
Terms used in exploratory mining, Introductory aspects of mine planning. Modes of entry to mineral deposits- adit or tunnel, Incline or vertical shaft. Exploratory surface mining of mineral and placer deposits, Open-pit mining methods.
Physical and mechanical, strength of rocks, Geological observations and records of underground excavations, Classification of underground excavations and methods of excavations, Shapes and cross-sectional dimensions of mine openings.
Techniques of Driving Mine Openings : Mining work and mining machinery. Drilling and blasting in excavations of mine openings. Electric power supply. Aeration of faces and drives of development openings. Loading of blasted muck. Underground support works. Mine drainage.
Organisation of the drifting cycle : Patterns and methods of work organisations. Calculation of major parameters of the drifting cycle.
Organisation and Mechanisation of Underground Excavation : Techniques. High speed driving of cross-cuts and entries. Excavation of inclined workings. Support of junctions.
Technical and Economic Characteristics of driving development Workings : Progress in machine driving of development openings. Rate of advance of development openings and labour productivity. Comparison of broad and narrow face driving.
Exploratory underground mining methods for open stoping sublevel open stoping, Room and pillar mining and shrinkage stoping.

Gunacc

Cycles of operation- drilling, blasting, mucking, support and lining, ventilation, illumination, and drainage.

Environmental baseline data needed for mine planning its acquisition and documentation during different stages of mineral exploration.

Nature and extent of environmental problems due to surface and underground mining.

Mine waste management. Role of the geologist at operative mines. Economic appraisal of mines.

Text Books:

1. Onika D. (1978): *Excavation of Mine Openings*, Mir Publishers
2. Boky B. (1967): *Mining*, Mir Publishers, 763p

Photogeology, Geoinformatics, and Mapping Techniques

Course Title: Photogeology, Geoinformatics, and Mapping Techniques — **Full Marks: 35**
Course No.: GEO 614a — **Pass Marks: 14**
Nature of the course: Theory — **Year: Second**

Course Description: The course on remote sensing provides the essentials of the photogeology and various maps prepared from the aerial photographs.

General Objective: To give in-depth knowledge and understanding of photogeology and mapping techniques.
Specific Objective: To provide the students with in-depth knowledge and practical skills of, Aerial photo interpretation, Preparation of geological, engineering, geological and other maps from aerial photographs and their use in geology.

Course Contents:
Introduction : Development in aerial and space photography, Advantages and limitations of photogeological techniques, Changes in conventional geological surveying.
Aerial Photography : Photographic flight mission and layout, Type of aerial photography, Use of conventional aerial photography, Stereoscopy and vertical exaggeration.
Geometric Characteristics of aerail photographs : Introduction, Terminology, Mosaic construction and use, Stereoscopic parallax, Basic geometrical relations of scale, Parallax and heights using vertical photographs.
Space missions and spectrozonal photography : Advances in photo9graphic techinques, Types of camera, Films and filters, Use of spectrozonal photography, Inportant space photographic missions.
Instrumentation : Working principle of instruments used for stereo-viewing measuing and plotting, Methods quantitative determination of geological data including dip, stratigraphic thickness, throw etc.
Photointerpretation : Principles. Elements of photo-interpretations geotechnical elements such as draingae, soil, landforms and vegetation, convergence of evidence.
Applications
Photogeological techniques in geomorphology, Lithological and structural interpretation, Soil, Groundwater, Engineering geology, Mineral exploration etc.
Maps : Type of maps - General geology, Engineering geology, Natural hazard, Hydrogeology, Water quality, Environmental geology.
Preparatory procedure of maps- Selection of parameters, Grading of the parameters, Interpretation of parameter, Drawing of each parameter, Printing map, Writing explanation text.
Terrain evalution.

Course Title: Photogeology, Geoinformatics, and Mapping Techniques
Course No.: GEO 617
Nature of the course: Practical

Full Marks: 15
Pass Marks: 06
Year: Second

Course Contents:
Study of aerial photographs with the help of stereoscopes.
Quantitative determination of geological data including dip, stratigraphic thickness, throw, and the like.
Aerial photointerpretation of various geological and geomorphological features.

Textbooks:

1. Miller V.C. and Miller C.F. (1961):*Photogeology*, Mc Graw-Hill, New York,
2. Pandey S.N.T. (1987): *Principles and Applications of photogeology*, Wiley Eastern New Delhi.
3. Marcolongo B. and Franco M. (1997): *Photogeology: Remote Sensing Applications in Earth Science*, Oxford and IBH Delhi, 195 p.

Course Title: Field Work **Full Marks: 50**
Course No.: GEO 614b **Pass Marks: 20**
Nature of the course:Practical **Year: Second**

Course Description: Field work is carried out to provide the field knowledge of industrial minerials industrial rocks, their texture, structure The students will lern techniques and skills of observation, data recording, sampling, description, analysis, interpretation and mapping ofindustria rocks and minerials in the field in the open and underground excavations.

General Objective: To give the knowledge, techniques and skill of minerial exploration and mapping the minelarization zones and in the field and in the.
Specific Objective: To provide the students with the techniques of

- Describing rock outcrop,. underground and open excavations
- Mapping of rock outcrop and minelarization zones.
- interpretation of texture and structure and minerial occurences and .
- Preparation of minelarization maps and cross-sections.

Course Contents:
Location: The fieldwork will be carried out in in various parts of Nepal including minelarization zones, river vallys and watershades. The location may vary depending upon the criteria set by the Department
Introduction: Study of topographical and geological maps of the area, identification of main lithological, stratigraphic and monerological charecterstics of the area.
Mapping: Preperation of root maps andstudy of mimeral occurances. Mapping of mineral deposites and interpretation of their origin. Application of various mineral exploration techniques. Calculation of reserves. Techniques of mineral search and exploration. Preperation of tunnel logs. Preperation of the mineralization maps in 1:50,000, 1:25,000 1:2,000 and larger scales.
Interpretation: Inerpretation of the data on the basis of field informations. Use ofexploration techniques and search of mineral occurances. Interpretation of mineral deposites.
Field report: The field report includes chapter on regional setting, previous works, lothology, stratigraphy and mineralogy of ores deposits, structural interpretation of the area and maps showing mineralization zones and cross-sections across them. Apart from the report, the students will collect relivant rocks and mineral samples. The students prepare drawings, maps, and field note books contanning all the relevant informations. In the laboratory, the students will make thin sections and polished sections and also carry out necessary chemical analysis and interpretation of the data.

Textbooks:

1. Levinson A. A. (1980): *Introduction to Exploration Geochemistry*, Applied Publishing Limited, 924 p.
2. Barnes J. W. (1981) : *Basic Geological Mapping*, Geological Society of London Handbook Series, No. 1 Open University Press.

3. Hawkes H. E. and Webb J. S. (1980): *Geochemistry in Mineral Exploration, Second Edition,* Harper and Row,
4. Soloviov A. P. (1987): *Geochemical Prospecting*, Mir Publishers, 287 p.
5. Smirnov V. I. (1989): *Geology of Mineral Deposits*, Namechand and Brothers, 520p.

Reference Books:

1. Journal of Nepal Geological Society (various issues).
2. Bulletien of Department of Geology. (various issues).

Dissertation

Course Title: Dissertation
Course No.: GEO 618
Nature of the course: Practical

Full Marks: 100
Pass Marks: 40
Year: Second

Table 3b: Second year
Stream: Mapping and Analysis

Theory

Course No.	Courses Title	Full Marks	Pass Marks
GEO. 621	Global Tectonics and Basin Analysis	70	28
GEO. 622a	Geohazards and Environmental Geology	50	14
GEO. 622b	Groundwater Hydrology	35	20
GEO. 623a	Palaeontology	35	14
GEO. 623b	Techniques of Structural Analysis	35	14
GEO. 624a	Photogeology, Geoinformatics,and Mapping Techniques	35	14
GEO. 624b	Fieldwork	50	20

Practical

Course No.	Courses Title	Full Marks	Pass Marks
GEO. 625	Global Tectonics and Basin Analysis	30	12
GEO. 626	Groundwater Hydrology	15	06
GEO. 627a	Palaeontology	15	06
GEO. 627b	Techniques of Structural Analysis	15	06
GEO. 628	Photogeology, Geoinformatics, and Mapping Techniques	15	15
GEO. 629	Dissertation	100	40

Global Tectonics and Basin Analysis

Course Title: Global Tectonics and Basin Analysis — **Full Marks: 70**
Course No.: GEO 621 — **Pass Marks: 28**
Nature of the course: Theory — **Year: Second**

Course Description: Global Tectonics deals with the large-scale features of the earth's crust and their componental parts. The course also provides the skills and techniques of study, analysis, and interpretation of the these structures and their development in space and time.

General Objective: To give in-depth knowledge and understanding of the large-scale structure of the earth's crust and their various componts.

Specific Objective: To provide the students with in-depth knowledge and practical skills for the study, analysis, and interpretation of:

- geocynclinal concept and other previous concepts,
- continents,
- oceans,
- Plate Tectonics, and
- Kinematic and dynamic interpretations.

Course Contents:

Global Tectonics : Introduction. Historical background: Earlier hypotheses of orogenesis, Continental drift and mountain building. Global characters: Earth and its shape, size, and internal structure, Physiographic features and crustal types, Seismic, density, thermal, and chemical characters of crust, mantle, and core. Plate boundaries: Definitions, Types of plates boundaries, Pole of rotation of plates.

Accretionary plate boundaries: Physiography, Gravity, seismic, and magnetic anamoly patterns, Magmatism and metamorphism along mid-oceanic ridges.

Transform plate boundaries: Physiography, Seismic patterns, Types of transform faults and their relation to slipping rates, Study of a few typical transform faults.

Consuming plate margins: Physiography, Gravity and seismic patterns, Sedimentation, Magmatism and metamorphism patterns, Marginal basins, Development of island arcs.

Plate tectonics and Cenozoic mountain building: Configuration of different plates, Modals of mountain building, Pacific and andian Types orogenies, Collision tectonics, Thermal models, Plate tectonics, Obduction and ophiolite emplacement.

Plate tectonics and Indian plate: Configuration of the Indian plate, Ninety degree east ridge, Chaman transform fault, Tectonics of the Himalaya and its origin.

Mechanism of plate motion: Convection current models, Hot spots, Mantle plumes and triple junctions, Continental and oceanic rifts.

Plate tectonics through geological time: Stone belts and proterozoic belts gross characters, Structural trends, Magmatism and metamorphism, Sedimentation, Plate tectonic models.

Basin analysis : Principles of basin analysis. Definition and classification of basins, Overview of their stratigraphic and tectonic aspects, Importance of time classification, Purpose and approaches of basin analysis.

Method of basin analysis: Regional and detailed analysis, Conventional and synenergic approaches, Use of computers in qualitative and quantitative stratigraphic-facies and structural analysis.

Data acquisition techniques: Field mapping: Geological, geophysical, and geochemical field mapping techniques.

Remote sensing: Airphoto, landsat, and remotely sensed data, Modern methods of computer integration.

Laboratory data: Geochemical, sedimentological, paleontological, and palynological sample collection for regional and detailed analysis from cores and specimens in subsurface and surface, Types of specific laboratory studies, Use of computers in data base generation.

Log data: Application of subsurface log data in basin evaluation, Planning of log combination for effective interpretation.

Analytical studies

Regional tectonics: Time cross section, Isopach maps, Interpretation of framework in space and time, Examples.

Detailed structural style: Basement configuration from geological and geophysical data, Basinal fill maps, Detailed framework interpretation, Examples.

Stratigraphic studies: Rock-stratigraphic correlation, Time-stratigraphic correlation, Formal informal classification stratigraphic columns, Examples.

Facies studies: Facies mapping in two and three dimension, Vertical and horizontal sandshale, Elastic- nonelastic ratio profiles, Fence and block diagrams, Facies analysis and seismic stratigraphy, Sedimentology modelling.

Paleostructural and geohistory studies: Construction of paleo-structural sections and tectonic evolution in time, Examples.

Subsidence history: Subsidence history curve, Area frame of source rock maturity, Examples.

Hydrogeological and hydrodynamic studies: Salinity studies in space and time, Potentiometric maps interpretation principles, Examples.

Conservation of mineral deposits: Effect of younger dynamic processes viz. tectonic inversion, hydrodynamic movements, weathering, percolations, etc. on the mineral accumulations, hydrogeological hydrodynamic maps and conservation of mineral deposit maps, Examples.

Synthesis: Integration of multidiscipline – structural , sedimentological, geophysics, geochemistry, and hydrology discipline, Identification of prospects in space and time.

Course Title: Global Tectonics and Basin Analysis **Full Marks: 30**
Course No.: GEO 625 **Pass Marks: 12**
Nature of the course: Practical **Year: Second**

Course Contents:

Geochemical, sedimentological, paleontological and palynological studies of various regions. interpretation of plate movememts. Regional and detailed analysis from cores and specimens in sub surface and surface.Use of computers in data base generations.Log data: Subsurface log data in basin evolution.Pllaning of log combinations for effective interpretation.Analytical studies.

Preperation of thin cross-sections, isopatch maps, interpretation of framework in space and time.

Study of basement configuration from geological and geographysical data. Basinal fill maps, Detailed framework interpretation.

Rock statigraphic correlation, formal and informal classification of statigraphic columns.

Facies mapping in two and three dimensions,vertical and horizontal sandshale, elastic - nonelastic ratio profiles, fence and block diagrams, facies analysis and sesmic stratigraphy, sedimentological modelling.

Subsidence history: Subsidence curve, area frame aof sourse rock maturity.

Paleostructural and geohistiry studies: construction of palaeo- structural sections and tectonic evilution in time.

Tecto- economic analysis: structural method of probability analysis - Monte carlo, Delphi methods etc., Prospect analysis, examples.

Exploration planning: Short and long term planning, financial verses technical analysis for exploration priorites.

Textbooks:

1. Le Pichon X., Francheteau J., and Bonnin J. (1976): *Plate Tectonics*, Elsvier, Second Edition, 311 p.
2. Bayly B. (1991): *Mechanics in Structural Geology*, Springer-Verlag, 253 p.
3. Wyllie P. J. (1976): *The dynamics of earth* John Wiley &Sons Inc.,New York
4. Alan Cox (19): *Geomagnetic reversals and plate tectonics,* John Wiley &Sons Inc.,New York
5. Wiandley- *The evolving continents,* John Wiley &Sons Inc.,New York
6. Einsele G. (1992): *Sedimentary Basins*, Springer Verlag, 628 p.
7. Miall A. D. (1984): *Principles of Sedimentary Basin Analysis*, Springer Verlag

Reference Books:

1. Yin A. and Harrison T. M. (eds.) (1996): *The Tectonic Evolution of Asia*, Cambridge University Press, 666 p.
2. Shakleton, R. M., Dewey J. F., and Windley B. F. (eds.) (1988): *Tectonic Evolution of Himalayas and Tibet*, Cambridge University Press, 325 p.

3. Spencer (1977): *Introduction to the Structure of the Earth*, McGraw Hill Kogakusha, 640 p.
4. McClay K. R. (1987): *The Mapping of Geological Structures*, John Wiley & Sons Inc., 161 p.
5. R. (1979): *Lithostratigraphic analysis of Sedimentary Basin*, Conybear, Academic Press
6. Merrium D. F. (19..): *Quantitative techniques for analysis of sediments*
7. Fisher W.L. and Brown C.F.(19..): *Basin analysis and seismic stratigraphy*.
8. A.G.U- *Plate tectonics*

Geohazards and Environmental Geology

Course Title: Geohazards and Environmental Geology **Full Marks: 50**
Course No.: GEO 622a **Pass Marks: 20**
Nature of the course: Theory **Year: Second**

Course Description: The course on remote sensing provides the essentials of the natural hazard and environmental geology.

General Objective: To give in-depth knowledge and understanding of natural hazards and environmental geology.
Specific Objective: To provide the students with in-depth knowledge and practical skills of

- Interaction between the earth and man
- The earth system and biosphere,
- Earth processes and geological hazards, and
- Natural resources and environment

Course Contents:
Introduction: Earth, man and environment. Basic environmental problems. Growth of environmental science, and resource management vis-a-vis population. Geoscience factor in environmental planning. Environmental geosciences-fundamental concepts.
The Earth Systems and Biosphere: Conservation of matter in various geoshperes-lithosphere, hydrosphere, atmosphere and biosphere. Energy budget of the earth. Earth's thermal environment and seasons. Concepts of ecology. Ecosystems-flow of energy and matter. Coexistence in communities-food webs. Biogeographical zonations of earth. Ecological succession, adaptation, migration and extinction. The earth's major ecosystems-terrestrial and aquatic. General relationship between landscape. Climate and blooms.
Earths processes and geological hazards: Earths processes. Concept of residence time and rates of natural cycles. Catestrophic geologica hazards. Landslides. Classification of landslides, Landslide in Nepal, Study of individual landslides. Volcanic activity, Earthquakes.
Hazards and risks. Introduction, Hazards, Risks, Use of hazards and risks in decision- making on hill roads, Assessment of hazards and risks.
Study of floods, landslides, earthquakes, volcanism and avalanches, with a vies to asses the magnitude of the problem, prediction and perception of the hazards and adjustments to hazardous activities.
Ecology and bioengineering: Ecological concerns of roadside plantations. Bioengineering in slopes and slope failures.
Mineral resources and environment: Resources and reserves minerals and population. Oceans as new area for exploration of mineral resources. Urban ore and recucling of resources. Environmental impact of exploitation. Processing and smelting of minerals.
Energy resources and environment: Energy crisis. Consumption and production trends of energy resources. Environmental effects associated with

each type of energy resources. Environmental effects associated with each tyoe of energy resources, viz. petroleum, natural gas, hydropower, nuclear , coal, biomass, solar and wind energy. Future trends.

Water resources and environment: Global water balance. Ice sheets and fluctuations of sea levels. Origin and composition of sea water. Resources of oceans. Ocean pollution by toxic wastes. Human use of surface and groundwaters, goundwater polluion.

Landuse planning: The landuse plan, soil surveys in relation to landuse planning. Methods of site selection and evaluation-cost-benefit analusis versus physiographic determinism. Landscape aesthetics-evaluation of scenic resources. Environmental impacts of landuse. Some cas histories.

Waste Disposal: Solid waste disposals-geology in planning and siting of land fills. Problems of deep well disposals. Monitoring of disposal wells. Radioactive waste management.

Environmental health: Biogeochemical factors in environmental health. Human use, trace elements and health. Possible effects of imbalance of some trace elements. Diseases induced by human use of land.

Environmental law: Environmental legislation in Nepal.

Textbook:

1. Lundegren, *Environmental Geology*, Prentic Hall, New York

References:

1. Coats, *Environmental Geology*, John Wiley &Sons Inc.,New York
2. Vildiya, K. S., *Environmental Geology*, Tata Mc Graw Hills , India.

Groundwater Hydrology

Course Title: Groundwater Hydrology **Full Marks: 35**
Course No.: GEO 622b **Pass Marks: 14**
Nature of the course: Theory **Year: Second**

Course Description: The course on groundwater hydrology provides the essentials for the exploration, drilling, development, and management techniques of groundwater.

General Objective: To give in-depth knowledge and understanding of groundwater hydrology.
Specific Objective: To provide the students with in-depth knowledge and practical skills of

- Groundwater exploration,
- Well hydraulics, well design, well drilling, and development techniques, and
- Groundwater monitoring.

Course Contents:
Groundwater exploration : Hydrogeologic reports. Maps. Aerial photographs. Formation sampling. Geophysical exploration methods. Analysis of aquifers using pumping test data.
Well hydraulics : Definition of terms. Nature of converging flow. Cone depression. Equilibrium well equations. Nonequilibrium well equation. Modified nonequilibrium equation. Hydrogeological conditions that affect time-drawdown graphs. Calculating drawdown for intermittent pumping situations. Distance-drawdown graphs Well interference. Well efficiency. Radius of influence. Recharge and boundary conditions. Combined use of semilog graphs. Effect of partial penetration. Water- level recovery data. Theis nonequilibrium well equation. Other methods of aquifer analysis.
Well drilling methods : Cable tool method. California stovepipe method. Direct rotary drilling. Drilling fluids. Reverse circulation rotary drilling Air drilling systems. In-verse drilling. Dual-wall reverse circulation rotary method. Drill-through casing driver. Jet drilling. Hydraulic-percussion method. Boring with earth augers. Driven wells. Drilling procedures when boulders are encountered. Fishing tools. Grouting and sealing well casing. Plumbness and alignment.
Drilling fluids : Types of drilling fluids. Functions of a drilling fluid. Properties of water-based drilling fluids. Treatment of mix water for drilling fluids. Mixing additives into water-base systems. Air drilling. Drilling fluid additives. Guidelines for solving specific drilling fluid problems. Typical drilling problem.
Well screens and method of sediment-size analysis : Continuous-slot screen. Other types of well screens. Sediment-size analysis.
Water well design : Casing diameter. Casing materials. Well depth. Well screen length. Well screen slot openings. Pressure-relief screens. Formation stabilizer. Well screen diameter. Open area. Entrance velocity. Screen transmitting

capacity. Selection of material. Design of domestic wells. Design for sanitary protection. Special well designs.

Installation and removal of well screens : Pull-back method. Open-hole methods for screen installation. Filter packed wells. Installation of plastic screens. Bail-down procedure. Wash-down method. Jetting method. Installing well points. Removing well screens.

Development of water wells : Well development. Factors that affect development. Well development methods. A comparison of three development methods. Use of polyphosphates in development. Development of rock wells. Allowable sediment concentration in well water. Aquifer development techniques.

Collection and analysis of pumping test data : Conducting a pumping test. Measuring drawdown in wells. Well efficiency. Step-drawdown tests. Problems of pumping test analysis.

Water well pumps : Variable displacement pumps. Positive displacement pumps. Pumps used to ciculate drilling fluid. Air-lift pumping. Pump selection. Water storage.

Water-quality protection for wells and nearby groundwater resources : Choosing a well site. Predicting the pollution potential at a drilling site. Well design. Disinfection procedures required to maintain a sanitary well during drilling. Disinfecting wells and piping. Sealing and wellhead. Horizontal suction lines. Pitless adaptors. Sealing abandoned wells.

Well and pump maintenance and rehabilitation : Major causes of deteriorating well performance. Well failure caused by incrustation. Well failure caused by iron bacteria. Well failure caused by physical plugging of screen and surrounding formation. Importance of screen design on rehabilitation. Well failure from corrosion. Pump maintenance.

Groundwater law. Water well specifications. Contract problems.

Groundwater monitoring technology : Major federal legislation pertaining to groundwater quality and monitoring procedures. Groundwater contamination sources. Effect of aquifer characteristics on the spread of groundwater contamination. Delineating contaminant plumes. Monitoring contaminant movement (transport). Locating monitoring wells. Personnel safety at monitoring sites. Design of monitoring wells. Sampling monitoring wells. The task of groundwater protection. Aquifer restoration.

Alternative uses for wells and well screens : Dewatering. Well-point systems used for water supply. Infiltration galleries. Collector wells. Injection wells. Pressure-relief wells. Wells for heat pumps. Surface-water withdrawal.

Water treatment : Components of water treatment and waste treatment systems. Treatment technologies appropriate for meeting drinking water regulations. Point-of-use water treatment systems.

Wise use of groundwater

Estimating groundwater use, recharge, and volume in storage. Impact of droughts on groundwater supply and use. Managing groundwater supplies.

Evaluation of mineral deposits. The geological service of mining enterprises.

Course Title: Groundwater Hydrology **Full Marks: 15**
Course No.: GEO 626 **Pass Marks: 06**
Nature of the course: Practical **Year: Second**

Course Contents:

Sieve analysis and grain size distribution- Calculation of Hydraulic Conductivity by Hazen method.

Thiessen polygon diagrams and calculation of average depth of rainfall.

Preparation of flow nets and determination of groundwater flow directions. Problems related to flow nets.

Problems related to aquifer characteristics and well hydraulics: total head, pressure head and elevation head of the wells. Groundwater storage, discharge, recharge, velocity, radius of influence, drawdown at distances. Reynolds number and Darcy's law application.

Processing the pumping test data and calculation of storage coefficient, transmissivity, hydraulic conductivity from pumping test data using Theiss method. Waltons method. Jacobs method and recovery method.

Well parameters like specific capacity, well loss formation loss, well efficiency.

Water chemistry and various methods of data presentation.

Preparation of hydrogeological maps.

Groundwater modelling.

Textbooks:

1. Todd, K.D.,(1980), *Groundwater Hydrology (2nd ed.)*, John Wiley &Sons Inc.,New York
2. Driscoll, F.G.,(1989), *Groundwater and Wells.*, Johnson Filtration Systems Inc.,Minnesita
3. Fetter, C.W.,(1990), *Applied Hydrology(2nd ed.)*, CBS Publishers India

Reference Books:

1. Lloyd, J.W. (1981), *Groundwater Resources Evaluation*
2. Jones, G.P. and Rushton, K.R. (1981) *Pumping -test analysis*. Groundwater Resources Evaluation(Lloyd)
3. Raghunath, H.M. (1992), *Groundwater (2nd ed)* Wiley Eastern Limited, New Delhi, India.
4. Garg, S.P. (1982), *Groundwater and Tubewells (2nd ed.)* Oxford and IBH publishing Co. Ltd. New Delhi.

Plaeontology

Course Title: Plaeontology
Course No.: GEO 623a
Nature of the course: Theory

Full Marks: 35
Pass Marks: 14
Year: Second

Course Description: This course provides studends the concept and principles of palaeontology, the organic world of the past and its applications.

General Objective: To apply the palaeontological data to various geologic and biologic problems.
Specific Objective: To provide the knowledge, skills, and techniques of collecting, preparing, describing, and identifying fossil plants, invertebrates and vertebrates.

Course Contents:
Principles of Palaeontology : Origin of life. Precambrian Evolution of Prokaryotes and Protists; Precambrian Metazoan; Origin of Hard Parts; Late Precambrian-Early Cambrian Metazoan Diversification; Terrestrialization. Rules of Nomenclature; Species concept in Palaeontology; Describing Specimen; Cladistics. Fossil Record and the Evolutionary Process; Speciation; Patterns of Diversification; Coevolution; Adaptation; Rate of Evolution; Mass Extinction – Processes and Events.
Types of Fossils; Processes of Fossilization; Fossils concentration – Life and Death Assemblages; Fossil-Lagerstatten.
Functional Morphology – Fossils. Function and Phylogeny.
Palaeoecology – Fundamental Ecological Principles; Ecosystem; Life Habits; Fossil Communities; Fossils as Environmental Indicators.
Biogeography - Island Biogeography and Vicariance Biogeography; Biotic Distributions; Palaeobiogeography; Determining Geographic Ranges of Extinct Taxa; Climate of the Past. Biostratigraphy; Correlation with Fossils; Zone Fossils.
Trace Fossils
Taxonomy; Morphologies; Applications.
Micropalaeontology : Their importance in Geology; Methods and Technique in Micropalaeontology.
Introduction to various groups of Microfossils; Classification. Morphology. Ecological significance and Evolutionary trend of Foraminifra, Radiolaria, Ostracods, Conodonts and Diatoms.
Palaeobotany : Palynology – Aim and Scope; Morphology of Spores and Pollens.
Introduction to morphology, environmental and stratigraphical significance of Dinoflagellate, Nannoplanktons, Calcareous Algae and Stromatolites.
Leaf Morphology; Taxonomy, and ecological significance of the selected megafossils of Gondwana Supergroup and the Tertiary Floras.

Vertebrate Palaeontology : Scope and application of Vertebrate Palaeontology. Overview of the Vertebrate Classification; Vertebrate Origin, oldest chordate and the oldest vertebrate; Landmarks in Vertebrate Evolution.

Introduction to the evolution and palaeobiology of the Early Fishes, the Early Tetrapods and Amphibians, the Early Amniotes, Triassic Reptiles, the birds, and the mammals.

Problems of life on land; the Pattern of mammalian evolution; Extinction in the Ice Ages.

Human Evolution; the Early Fossil Record of Primates; the Last two million years of Human Evolution.

Indian subcontinent Pre-Tertiary Vertebrates: their Distribution, Affinity and Palaeobiogeographic implications; the Extinction of the Dinosaurs. Indian subcontinent Tertiary Vertebrates: the Siwalik Mammals; Phylogeny of Equidae and Probosidae. Fossil Hominoids from the Indian subcontinent.

Course Title: Placontology **Full Marks: 15**
Course No.: GEO 627a **Pass Marks: 06**
Nature of the course: Practicals **Year: Second**

Practicals

Practical Techniques in Palaeontology
Collecting fossils in the field
Preparation of Macrofossils
Extraction of Microfossils
Photography
Electron Microscopy
Practical in Micropalaeontology
Morphological description of selected taxa
Practical in Palaeobotany
Morphological description of selected taxa
Practical in Vertebrate fossils
Morphological description of selected taxa

Textbooks:

1. David M. Raup and Steven M. Stanley1985: *Principles of Palaeontology, 2nd Edition*, CBC Publishers and Distributers, Delhi.
2. Michael J. Benton, 1997: *Vertebrate Palaeontology, 2nd Edition*, London: Chapman and Hall.
3. Bromley, 1990: *Trace Fossils, Biology and Taphonomy*, London: Unwin Hyman.
4. Brasier, M., 1980: *Microfossils* , London: Allen and Unwin.
5. Stewart, 1983: *Palaeobotany and the Evolution of Plants*, Cambridge University Press.

Reference Books:

1. Derek E. G. Briggs and Peter R. Crowther (eds.), 1990: *Palaeobiology – A Synthesis*, London: Blackwell Science.
2. Allen and D. E. G. Briggs, 1990: *Evolution and the Fossil Records*, Washington, D. C.: Smithsonian Institution Press.
3. Andrew B. Smith, 1994: *Systematics and the Fossil Records*, London: Blackwell Scientific Publications.
4. Jeffrey J. Thomason (editor), 1995: *Functional Morphology in Vertebrate Palaeontology*, Cambridge University, Press.
5. Bruce J. MacFadden, 1992: *Fossil Horses*, Cambridge University Press.
6. Edited by D. B. Weishapel, Peter Dodson and Halszka Osmolska (eds.), 1990 : *The Dinosauria*, University of
7. California Press.
8. Alan Feduccia, 1996 : *The Origin and Evolution of Birds*, Yale University Press.

Techniques of Structural Analysis

Course Title: Techniques of Structural Analysis **Full Marks: 35**
Course No.: GEO 623b **Pass Marks: 14**
Nature of the course: Theory **Year: Second**

Course Description: The course gives the necessary knowledge and skills of analysis and interpretation of geological structures.

General Objective: To give in-depth knowledge and understanding of structural analysis techniques.
Specific Objective: To provide the students with in-depth knowledge and practical skills of

- Microscopic, mesocopic, and macroscopic analysis of structural data,
- Geometrical, kinematic, and dynamic interpretations,
- Their use in geology.

Course Contents:
Introduction : Historical Background. Structural analysis. Significance of Symmetry.
Tectonic fabric and its geometrical analysis : The tectonite fabric. Geological bodies of various scales. Homogeneous and heterogeneous geological bodies. Fabric of geological bodies. Isotropic and anisotropic fabric. Concept of tectonite fabric. Symmetry of tectonite fabric.
Grafical treatment of fabric data. Data of structural analysis. Equal-area projection in structural analysis. Significance of orientation diagrams. Rotation of fabric data.
Mesoscopic analysis. Mesoscopic structures and fabrics. Procedures in mesoscopic analysis. Planar structures. Linear structures. Folds. Mutual relations of associated mesoscopic structures.
Macroscopic analysis. Macroscopic bodies. Macroscopic structures. Macroscopic fabrics. Analysis of macroscopic folds and fold systems. Macroscopic analysis of lineations. Macroscopic analysis of mesoscopic folds. Homogeneity and symmetry of macroscopic domains.
Microscopic analysis. Preparation of oriented sections. Universal stage procedures. Microscopically visible fabric elements and domains. Microscopic analysis of preferred orientation. Relation of microscopic to mesoscopic subfabrics an structures.
Interpretation of Tectonite Fabrics : Direct and indirect componental movements. Homogeneous deformation of tectonite fabric. Analysis of deformation. Interpretation of tectonite fabrics. Transformation of passive markers by homogeneous deformation. Kinematic axes of movement pictures. Interpretation of microscopic subfabrics: Preprerred orientation of tectonite minerals. General interpretation. Preferred orientation of individual minerals. Interpretation of foliation and lineation. The general problem. Broad relations of foliation and lineation to movement and mean strain. Common

Combinations of foliation and lineation: detailed dynamic and kinematic interpretation.

Folding in tectonites: Interpretation of folds as heterogeneous structures. Introduction. Heterogeneous deformation in concentric and in similar folds. Flexural-slip folding. Slip, shear, and flow folding. Generalised kinmatic models of folding in tectonites. Superposed folding.

Folding in tectonites: Intepretation of fold systems. The general problem. Kinematic properties of fold systems. Kinematic significance of patterns of prefolding lineations. Unrolling of complex folds by graphic construction. Homogeneous fold systems and mean strains. Rheological aspects of folding in tectonites.

Stress : Stress notations. Stress components. Analysis of plane stress. Principal stresses. Invarients in plane stress. Stress acting on a plane. Stress in three dimensions. Stress invarients in three dimensions. Stress acting on any planar surface. Planes of maximum shearing stress. Hydrostatic and deviatoric stress.

Strain in two dimensions : Measurement of strain. Homogeneous and inhomogeneous strain. Finite and infinitesimal strain. Change in length of lines. Change in angles. Shear strain. The Mohr diagram. Strain invariants. Simple shear. Methods of graphically recording the shapes of the finite strain ellipse. Infinitesimal strain in two dimensions. Change in length of lines. Infinitesimal shear strain. Infinitesimal area change.

Strain in three dimensions : Finite strain in three dimensions. The finite strain tensor. Change in length of lines. Shear strain. Change in angle during deformation. Methods of graphically recording the components of finite strain. Determination of principal axes of the strain ellipsoid from two-dimensional data. Mohr construction for representing states of strain in three dimensions. Finite strain properties of five types of constant-volume ellipsoids. Dispersion of lines and planes as a result of strain. Superposition of two finite strains. Infinitesimal strain in three dimensions. Infinitesimal longitudinal strain. Infinitesimal shear strain. Mohr diamgram for infinitesimal strain. Infinitesimal volume change. Progressive deformation in three dimensions. Relationship of progressive deformation in two and three dimensions. Significance of cleavage and schistosity.

Relationship between stress and strain : Behaviour of rocks under experimental conditions. Deformation of polycrystalline aggergates. Rock behaviour in terms of mechanical analogs. Progressive deformation.

Course Title: Techniques of Structural Analysis **Full Marks: 15**
Course No.: GEO 627b **Pass Marks: 06**
Nature of the course: Practicals **Year: Second**

Course Contents:
Displacement: Change in length and angles. The strain ellipse concept: Distortion and rotation. An introduction to heterogeneous strain. Displacement vector fields and strain. Practical strain measurements: Initially circular and elliptical markers, lines, the centre to centre techniques and strain partitioning; angles. Orientation analysis. Strain in three dimensions: Planar and linear fabrics. Strain in three dimensions: Review of methods and representation of strain state. Progressive displacement and Progressive deformation. Measurement of progressive deformation: extension veins and pressure shadows.
Fold morphology. Fold orientations: Projection techniques. Fold classification. Fold sections and profiles. Fold mechanics: single layers, Multilayers. Strain and small-scale structures in folds. Superposed folding. Fault geometry and morphology. Faults and the construction of balanced cross sections. Mechanical analysis of fractures. Study of ductile and brittle shear zones. Study of joints.

Textbooks:
Turner F. J. and Weiss L. E. (1963): *Structural Analysis of Metamorphic Tectonites*, McGraw Hill Book Company, 545 p.
Ramsay J. G. (1967): *Folding and Fracturing of Rocks*, McGraw Hill Inc., 568 p.
Ramsay J. G. and Huber M. I (1983): *The Techniques of Modern Structural Geology, Volume 1: Strain Analysis*, Academic Press, 307 p.
Ramsay J. G. and Huber M. I (1987): *The Techniques of Modern Structural Geology, Volume 2: Folds and Fractures*, Academic Press, 309-700 p.
Reference Books:
Bayly B. (1991): *Mechanics in Structural Geology*, Springer-Verlag, 253 p
Johnson A. M. (1977): *Styles of Folding*, Elsevier Scientific Publishing Company, 406 p.
Hobbs B. E., Means W. D., and Williams P. F. (1976): *An Outline of Structural Geology*, John Wiley & Sons, 571 p.
Spencer (1977): *Introduction to the Structure of the Earth*, McGraw Hill Kogakusha, 640 p.
McClay K. R. (1987): *The Mapping of Geological Structures*, John Wiley & Sons Inc., 161 p.
Ragan D. M. (1985): *Structural Geology, An Introduction to Geometrical Techniques, 3rd edition*, John Wiley & Sons Inc., 393 p.

Photogeology, Geoinformatics, and Mapping Techniques

Course Title: Photogeology, Geoinformatics, and Mapping Techniques
Course No.: GEO 624a
Nature of the course: Theory

Full Marks: 35
Pass Marks: 14
Year: Second

Course Description: The course on remote sensing provides the essentials of the photogeology and various maps prepared from the aerial photographs.

General Objective: To give in-depth knowledge and understanding of photogeology and mapping techniques.
Specific Objective: To provide the students with in-depth knowledge and practical skills of

- Aerial photo interpretation,
- Preparation of geological, engineering, geological and other maps from aerial photographs, and
- Their use in geology.

Course Contents:
Introduction : Development in aerial and space photography, Advantages and limitations of photogeological techniques, Changes in conventional geological surveying.
Aerial Photography: Photographic flight mission and layout, Type of aerial photography, Use of conventional aerial photography, Stereoscopy and vertical exaggeration.
Geometric Characteristics of aerail photographs: Introduction, Terminology, Mosaic construction and use, Stereoscopic parallax, Basic geometrical relations of scale, Parallax and heights using vertical photographs.
Space missions and spectrozonal photography : Advances in photo9graphic techinques, Types of camera, Films and filters, Use of spectrozonal photography, Inportant space photographic missions.
Instrumentation: Working principle of instruments used for stereo-viewing measuing and plotting, Methods quantitative determination of geological data including dip, stratigraphic thickness, throw etc.
Photointerpretation : Principles. Elements of photo-interpretations geotechnical elements such as draingae, soil, landforms and vegetation, convergence of evidence.
Applications: Photogeological techniques in geomorphology, Lithological and structural interpretation, Soil, Groundwater, Engineering geology, Mineral exploration etc.
Maps: Type of maps - General geology, Engineering geology, Natural hazard, Hydrogeology, Water quality, Environmental geology.
Preparatory procedure of maps- Selection of parameters, Grading of the parameters, Interpretation of parameter, Drawing of each parameter, Printing map, Writing explanation text.
Terrain evalution.

Course Title: Photogeology, Geoinformatics, and Mapping Techniques
Course No.: GEO 628
Nature of the course: Practical

Full Marks: 15
Pass Marks: 06
Year: Second

Course Contents:
Study of aerial photographs with the help of stereoscopes.
Quantitative determination of geological data including dip, stratigraphic thickness, throw, and the like.
Aerial photointerpretation of various geological and geomorphological features.

Textbooks:
1. Miller V.C. and Miller C.F. (1961):*Photogeology*, Mc Graw-Hill, New York,
2. Pandey S.N.T. (1987): *Principles and Applications of photogeology*, Wiley Eastern New Delhi.
3. Marcolongo B. and Franco M. (1997): *Photogeology: Remote Sensing Applications in Earth Science*, Oxford and IBH Delhi, 195 p.

Reference Books:
1. Lillesand, T.M. and Kiefer, R.W., (1994) *Remote Sensing and Image Interpitation*, John Wiley and Sons Inc.,New York.

Field Work

Course Title: Field Work
Course No.: GEO 624b
Nature of the course:Practical

Full Marks: 50
Pass Mark: 20
Year: Second

Course Description : Fieldwork is carried out to provide the field knowledge of rocks, their texture, structure, and techniques and skills of observation, data recording, sampling, description, analysis, interpretation, and mapping of rocks and their structures in the field.

Objective :

General Objective : To give the knowledge, techniques, and skills of geological mapping and basin analysis in the field.

Specific Objective : To provide the students with the techniques of :

- Mapping of rock outcrop,
- Interpretation of secondary structures, folds, and faults, and
- Preparation of maps and geological cross - sections.

Course Contents :

Fieldwork :

Location: The fieldwork will be carried out in the Lesser and Higher Himalaya of Nepal. The location may vary depending on the criteria set by the Department.

Introduction: Study of topographical and geological maps of the area, identification of main lithological, stratigraphic, and structural features of the area and study of contacts of various rock units.

*Mapping:*Preparation of route maps and columnar sections of the important units. Mapping of lithological boundaries, tectonic contancts, and other structural features (folds, faults, joints, foliation, bedding, etc). Preparation of the geological maps in 1:50,000 and 1:25,000 scales.

*Interpratation:*Interpretation of the data on the basis of measured attitudes of beds and foliation. Use of stereographic projection in paleocurrent analysis and contouring the field data. Interpretation of geological structures and preparation of geological cross - sections.

*Field Report:*The field report includes chapters on regional setting, previous works, lithology, stratigraphy, and structural set up of the area, and geological maps and cross - sections. Apart from the report, the students also collect relevant rock samples and fossil samples. They prepare drawings, maps, and field notebook containing all the relevant information.

Textbooks:

1. Thrope R. S. and Brown G. C. (1995): *The Field Description of Igneous Rocks*, John Weiley & Sons, 154 p.
2. Barnes J. W. (1981) : *Basic Geological Mapping*, Geological Society of London Handbook Series, No. 1 Open University Press.

3. Tucker M. (1982) : *The Field Description of Sedimentation Rocks*, Geological Society of London Handbook Series, No., Open University Press.
4. Fry, N. (1984) : *The Field Description of Metamorphic Rocks*, Geological Society of London Handbook Series, No. 3 Open University Press.
5. McClay K. R. (1987): *The Mapping of Geological Structures*, John Wiley & Sons Inc., 161 p.

Reference Book:

1. Gansser A. (1964): *Geology of the Himalayas*, John Wiley & Sons Inc.
2. Journal of Nepal Geological Society (various issues).
3. Bulletien of Department of Geology. (various issues).

Course Title: Dissertation
Course No.: GEO 629
Nature of the course: Practical

Full Marks: 100
Pass Marks: 40
Year: Second

Table 3c: Second year
Stream: Engineering Geological Techniques

Theory

Course No.	Courses Title	Full Marks	Pass Marks
GEO. 631	Engineering Geology and Geotechniques	70	28
GEO. 632	Engineering Geophysics	70	28
GEO. 633a	Engineering Hydrology	50	20
GEO. 633b	Groundwater Hydrology	35	14
GEO. 634a	Remote Sensing and Geoeinformatics	35	14
GEO. 634b	Fieldwork	50	20

Practical

Course No.	Courses Title	Full Marks	Pass Marks
GEO. 635	Engineering Geology and Geotechniques	30	12
GEO. 636	Engineering Geophysics	30	12
GEO. 637	Groundwater Hydrology	15	06
GEO. 638	Remote Sensing and Geoeinformatics	15	15
GEO. 639	Dissertation	100	40

Engineering Geology and Geotechniques

Course Title: Engineering Geology and Geotechniques **Full Marks: 70**
Course No.: GEO 631 . **Pass Marks: 28**
Nature of the course: Theory **Year: Second**

Course Description: The coarse of engineering geology and geotechniques gives the necessary knowledge and skills of geological and geotechnical inputs necessary for investigation, design, and implementation of various engineering structures.

General Objective: To give in-depth knowledge and understanding of engineering geology and geotechnical engineering.
Specific Objective: To provide the students with in-depth knowledge and practical skills of

- Structures, and strength of soils and rocks,
- Strength of soil, rock and rock masses, and
- Investigation techniques of surface and subsurface structures.

Course Contents:
Soil formation, classification, and exploration : Introduction, Nature and composition of soils, Soil formation, Soil classification, Soil exploration, Laboratory testing.
Strength and deformation : Introduction, Principle of effective stress, Concept of failure, Principles of strength and deformation testing, Field testing for strength and deformation, Laboratory tests, Strength and deformation parameters of soils.
Flow of water through a soil mass : Introduction, Flow laws, Field measurement of permeability, Flow rate, Flow nets, Solutions of flow equation.
Settlement and consolidation : Introduction, Compressibility of soils, Rate of primary settlement, Multi dimensional settlement, Secondary compression measurement of soil parameters.
Retaining structures : Introduction, Limiting stress states in a soil mass, Intermediate stress state pressures on a rigid retaining wall, Passive pressure analyses, Stability analyses.
Stability of slopes : Introduction, Types of instability mechanisms, Methods of stability analysis, Stability, Applicability of analyses, Detection and control of landslides.
Foundations : Introduction, Foundation systems, Stability analyses, Stress distribution analyses, Settlement analyses of shallow foundations, Settlement analyses of piles, Laterally loaded pile, Raft (mat) foundations dynamic analyses of foundation, Concluding remarks.
Soil treatment : Introduction, Deep layers, Surficial layers.
Planning considerations : Introduction, Types of underground excavation, Underground excavation design.
Classification of rock masses : Introduction, Terzaghi's rock load classification, Classifications by Stini and Lauffer, Deere's rock quality

designation (RQD), Influence of clay seams and fault gouge, CSIR classification of jointed rock masses, NGI tunneling quality index, Discussion on rock mass classification systems.

Geological data collection : Introduction, Study of regional geology, Engineering geological maps and plans, Mapping surface outcrops, Geophysical exploration, Diamond drilling for sub-surface exploration, Index testing of core, Core logging and core photography, Core storage, Exploratory adits and shafts.

Graphical presentation of geological data : Introduction, Equal area and equal angle projections, Stereographic projection of a plane and its pole, Definition of geological terms, Construction of stereographic nets, Construction of a great circle to represent a plane, Determination of the line of intersection of two planes, Relationship between true and apparent dip, Plotting and analysis of field measurements, Computer processing of structural data collection, Isometric drawings of structural planes, Use of demonstration models in underground excavation design.

Stresses around underground excavations : Introduction, Components of stress, Two dimensional state of stress, In situ state of stress, stress distributions around single excavations, Stresses around a circular excavation, Circulation of stresses around other excavation shapes, Stresses around multiple excavations, Three-dimensional pillar stress problems, Stress shadows, Influence of inclination upon pillar stresses, Influence of gravity.

Strength of rock and rock mass : Introduction, Brittle and ductile behavior, Laboratory testing of intact rock samples, An empirical failure criterion for rock, Survey of triaxial test data on intact rock specimens, Simplifying assumptions, Anisotropic rock strength, Strength of rock with multiple discontinuities, Strength of heavily jointed rock masses, Use of rock mass classifications for rock strength prediction, Deformability of rock masses, Approximate equations defining the strength of intact rock and heavily jointed rock masses.

Underground excavation failure mechanisms : Introduction, Structurally controlled instability, Computer analysis of structurally controlled instability, Optimum orientation and shape of excavations in jointed rock, Influence of excavation size upon structurally controlled instability, Pillar failure, Fracture propagation in rock surrounding a circular tunnel, Sidewall failure in square tunnels, Influence of a fault on excavation stability, Buckling of slabs parallel to excavation boundaries, Excavations in horizontally bedded rock, Stiffness, energy, and stability.

Underground excavation support design : Introduction, Support of wedges or blocks which are free to fall, Support of wedges or blocks which are free to slide, Rock-support interaction analysis, Summary of rock-support interaction analysis, Summary of rock-support interaction equations, Examples of rock-support interaction analysis, Discussion on rock-support interaction analysis, Use of rock mass classification for estimating support, Comparison of underground excavation support predictions, Pr

Introduction, Objectives of underground instrumentation, Common inadequacies in instrumentation programs, Instrumentation for the collection of

design data, Monitoring of underground excavations during construction, Monitoring of underground excavations after construction, Monitoring of trial excavations.

Site exploration

Direct methods: General, Subsurface exploration of soils, Sampling in soils, Subsurface exploration in rocks, In situ testing. ,Indirect methods: Seismic method, Resistivity methods.

Classification of types of dam : Classification according to use, Classification by hydraulic design, Classification by materials- Earthfill, Rockfill, Concrete gravity, Concrete arch, Other types.

Physical factors governing selection of type

Topography, Geology and foundation conditions, Materials available, Spillway size and location, Earthquake.

Foundations and construction materials

Scope of investigations- General, Foundations, Embankment soils, Riprap and rockfill, Concrete aggregate.

Sources of information- Topographic maps, Geologic maps, Airpotos.

Surface exploration of damsite

Fluvial soils, Glacial deposits, Residual soils.

Subsurface exploratory methods

Test pits, trenches, and tunnels, Auger borings, Rotary drilling Standard penetration borings, Geophysical methods.

Tunnel investigation

Geological conditions and tunnelling, Tunnelling in soft ground, Water in tunnels, Gases in tunnels, Temperature in tunnels, Excavation of tunnels, Analysis of tunnel support.

Interpretation of aerial photographs

Landslides. Classification of landslides, Landslide in Nepal, Study of individual landslides.

Geological hazards

Volcanic activity, Earthquakes.

Maps : Type of maps - General geology, Engineering geology, Natural hazard, Hydrogeology, Water quality, Environmental geology.

Preparatory procedure of maps- Selection of parameters, Grading of the parameters, Interpretation of parameter, Drawing of each parameter, Printing map, Write explanation text.

Engineering geological map

Terrain evalution. Maps for engineering purposes.

Hazards and risks : Introduction, Hazards, Risks, Use of hazards and risks in decision- making on hill roads, Assessment of hazards and risks.

Ecology and bioengineering

Ecological concerns of roadside plantations, Bioengineering.

Course Title: Engineering Geology and Geotechniques **Full Marks: 15**
Course No.: GEO 635 **Pass Marks: 06**
Nature of the course: Practicals **Year: Second**

Practicals:

Methods of determination of engineering properties of soils and rocks in laboratory field.
Classificarion and terminology of damsand other engineering structures.
Preparation of log chart for drill core logging.
Analysis of water pressure test results.
General procedures of test grouting.
Preparation of 3-dimensional geological logs in tunnels.
Methods of treatments for stability of slope cuts.
Engineering classification of landslides and stability analyses using graphical methods.

Textbooks:

1. Lee I. K., White W. and Ingles O. G. (1983): *Geotechnical Engineering*, Pitman, 507 p.
2. Bell, F.G. 1980 *Engineering Geology and Geotechniques*,.John Wiley and Sons, New York
3. Bell F.G. 1982 *Fundamentals of Engineering Geology*.Aditya Books Pvt. Ltd., New Delhi, 648p
4. Hock and Bray J. (1977): *Rock Slope Engineering* Institute of Mining and Metallurgy, London, 358p

Reference Books:

1. Krynine, D.P. and Judd W.R. (1957): *Principles of Engineering Geology and Geotechniques*, John Wiley and Sons, New York
2. Legget R.F. and Hatheway (1988): *Geology and Engineering*, John Wiley and Sons, New York
3. Beavis F.C. (1985): *Engineering Geology*, John Wiley and Sons, New York

Engineering Geophysics

Course Title: Engineering Geophysics
Course No.: GEO 632
Nature of the course: Theory

Full Marks: 70
Pass Marks: 28
Year: Second

Course Description:

General Objective: To give in-depth knowledge and understanding of engineering geophysics and its application in engineering works
Specific Objective: To provide the students with in-depth knowledge and practical skills of

- Application of geophysics in subsurface investigation,
- Methods of exploration of groundwater, slopes, landslides, and dams

Course Contents:
Introduction: Introduction to exploration geophysics with the emphasis to engineering and environmental geophysics, geophysical survey design.
Gravity method: Geological and physical basis. Gravity meters. Corrections used in gravity method, Interpretation methods applications and case histories.
Magnetic method: Basic concepts and geological basis, Earth magnetic field, magnetic instruments, Magnetic surveying, qualitative and quantitative interpretation, applications and case histories.
Electrical and electromagnetic Methods: Electrical properties of rocks, Electrical resistivity methods: basic theory, layouts of electrodes, electrical profiling and sounding, 1-D and 2-D electrical resistivity methods, interpretation, application and case histories, Induced polarization method: basic theory, interpretation and case histories, Self potential method: basic theory, interpretation, application and case histories, Electromagnetic method: basic theory, continuous wave methods, application and case histories, time-domain EM methods, Very Low Frequency Method (VLF), Telluric and magneto-telluric methods, application and case.
Ground Penetrating Radar (GPR): Basic theory, radar reflection profiling, Field arrangement and interpretation.
Seismic methods: Theory of elasticity, seismic wave propagation, principles of exploration seismograph, sources of seismic energy, Seismic refraction method: time-distance relationships, Data acquisition in seismic refraction, interpretation by Plus-Minus method, Generalized Reciprocal Method, application and case histories. Seismic Reflection Method: time-distance relationship, Instruments, data acquisition and processing techniques, interpretation, application and case histories.
Radioactivity method: Theoretical background, radioactivity of rocks, Geophysical well logging: electrical logging, interpretation, Radioactivity logging, eleastic wave logging, thermal wave logging, interpretation

Course Title: Engineering Geophysics
Course No.: GEO 636
Nature of the course: Practicals

Full Marks: 30
Pass Marks: 12
Year: Second

Practicals:
Gravity data reduction and interpretation, Magnetic data reduction and interpretation, Electrical sounding interpretation, SP data interpretation, Ground conductivity, Seismic refraction data processing and interpretation, Geophysical well log interpretation, radioactive methods.

Textbooks:

1. Dobrin, M.B. and Savit, C.H., 1988. *Introduction to geophysical prospecting*. McGraw-Hill Book Company, 867 p.
2. Reynolds, J.M., 1997. *An Introduction to applied and environmental geophysics*. John Wiley & Sons, 796 p.
3. Telford, W.M., Geldart, L.P., Sheriff, R.E. and Keys, D.A., 1976. *Applied Geophysics, 2nd edn.* Cambridge: Cambridge University Press, 860 p.

Reference Books:

1. Richter C. F. (1969): *Elementary Seismology*, S. Eurasia Publishing House Pvt. Ltd., 768 p.
2. Keller, G. V. and Frischknecht, F. C., 1966. *Electrical methods in geophysical prospecting*. Pergamon Press, 517 p.
3. Parasnis, D.S., 1997. *Principles of applied geophysics*. Chapman & Hall, 429 p.

Engineering Hydrology

Course Title: Engineering Hydrology **Full Marks: 50**
Course No.: GEO 633a **Pass Marks: 20**
Nature of the course: Theory **Year: Second**

Course Description: Engineering hydrology gives in-depth understanding of movement of water in the atmosphere, hyrosphere, and on the surface and subsurface of the earth. It also discusses the various applications of hydrology in engineering designs.

General Objective: To give in-depth knowledge and understanding of engineering hydrology.

Specific Objective: To provide the students with in-depth knowledge and practical skills of

- Weather and hydrology,
- Precipitation,
- Stream flow and discharge,
- Runoff and subsurface flow, and
- Various applicaions of hydrology.

Course Contents:

Introduction : The hydrologic cycle. History. Hydrology in engineering. Subject matter of hydrology.

Weather and hydrology : Solar and earth radiation: Solar and earth radiation, Solar radiation at earth's surface, Heat balance of earth's surface and atmosphere.

The general circulation: Thermal circulation. Effects of earth's rotation. Jet streams. Effect of land and water distribution. Migratory systems. Fronts.

Temperature: Terminology. Measurement of temperature. Lapse rates. Geographic distribution of temperature. The variation of temperature.

Humidity: Properties of water vapor. Terminology. Measurement of humidity. Geographic distribution of humidity. Time variation in humidity.

Wind: Measurement of wind. Geographic variation of wind. Time variation of winds.

Precipitation : Formation of precipitation. Forms of precipitation. Types of precipitation. Artificially induced precipitation.

Measurement of precipitation: Precipitation gages. The precipitation-gage network. Rader measurement of precipitation. satellite estimates of precipitation.

Interpretation of precipitation data: Estimating missing precipitation data. Double-mass analysis. Average precipitation over area. Depth-area-duration analysis.

Variations in precipitation: Geographic variations. Time variation. Record rainfalls.

Snowpack and snowfall: Measurement. Variations.

Streamflow : Water stage: Manual gages. Recording gages. Crest-stage gages. Miscellaneous stage gages. Selection of station site.

Discharge : Reservoir evaporation. Combination methods of estimating reservoir evaporation. Estimation of reservoir evaporation from pan evaporation and related meteorological data. Summary and appraisal of techniques for estimating reservoir evaporation. Increased water supplies through reduced evaporation.

Transpiration: Factors affecting transpiration, measurement of transpiration.

Evapotranspiration: Water-budget - determination of mean basin evapotranspiration. Field-plot determination of evapotranspiration. Lysimeter determination of evapotranspiration. Estimating potential evapotranspiration from meteorological data. Estimating actual evapotraspiration from potential. Irrigation water requirements. Controlling evapotranspiration. Equations for evapotranspiration computations.

Subsurface water : Occurrence of subsurface water.Moisture in vadose zone: Soil-water relationships. Equilibrium points. Measurement of soil moisture. Movement of soil moisture. Moisture in phreatic zone: Aquifers. Movement of groundwater. Determination of permeability. Source of groundwater. Discharge of groundwater. Equilibrium hydraulics of wells. Nonequilibrium hydraulics of wells. Boundary effects. Aquifer analysis. Potential of a groundwater reservoir: Safe yield. Seawater intrusion. Artificial recharge. Artesian aquifers. Time effects in groundwater.

Streamflow Hydrographs : Characteristics of the hydrograph: Components of runoff. Streamflow recessions. Hydrograph separation. Analysis of complex hydrographs. Determination of total runoff.

Hydrograph synthesis: The elemental hydrograph. The unit-hydrograph concept. Derivation of unit hydrographs. Derivation of unit hydrograph from complex storms. The conversion of unit-hydrograph duration. Synthetic unit hydrographs. Application of unit hydrographs. Hydrograph of overland flow.

Relations between precipitation and runoff : The phenomena of runoff: Surface retention. Runoff mechanisms. The runoff cycle.

Estimating the volume of storm runoff: Initial moisture conditions. Storm analysis. Multivariate relations for total storm runoff. Relations for incremental storm runoff. Infiltration approach to runoff estimates. Infiltration indexes.

Estimating snowmelt runoff: Physics of snowmelt. Estimating snowmelt rates and consequent runoff.

Seasonal and annual runoff relations: Precipitation-runoff relations. Use of snow surveys.

Hydrological routing : Wave movement. Waves in natural channels. The storage equation. Determination of storage. Treatment of local inflow. Reservoir routing. Routing in river channels. Channel routing: Analytical methods. Channel routing: Graphical methods. Deriving basin outflow by routing. Gage relations.

Hydraulic routing : Governing equations. Dynamic wave velocity. Numerical techniques. Routing with complete equations. Kinematic routing. Zero-inertia routing.

Erosion. sedimentation. and the river basin

Physical descriptors of catchment form. Descriptors of catchment relief. Hydraulic geometry. Stream patterns. Floodplains. The erosion process. Factors controlling erosion. Suspended-sediment transport. Bad-material transport. Sediment measurement. Sediment-rating curves. Sediment yield of a catchment. Sediment simulation. Reservoir sedimentation.

Deterministic hydrologic models

Types of deterministic models. Structure of a conceptual model. Parameters and calibration. Other deterministic models. Snowmelt simulation. Reliability of hydrologic simulation.

Probability in hydrology: A basis for planning : Flood probability: Selection of data. Plotting positions. Theoretical distributions of floods. Log-Pearson type III distribution. Extreme-value type I distribution. Selection of design frequency. Regional flood frequency. Frequency analysis from synthetic data. Conditional probability. Frequency events.

Probability of runoff volume

Distributions. Drought.

Precipitation probability

Distributions. Generalization of rainfall-frequency data. Adjustment of fixed-interval precipitation amounts. Rainfall-frequency maps. Design storm.

Applications of hydrology : Data preparation. Record extension. Water-supply reservoirs. Flood regulation. Channel improvement for flood mitigation. Floodplain mapping. Urban storm drainage. Highway culverts. Spillway design. Cooling-pond design.

Textbook:

1. Fetter, C.W.,(1990), *Applied Hydrology(2nd ed.)*, CBS Publishers India

Reference Book:

1. Linsley R. K. , Kohler M. A. and Paulhus J. L. H. (1994) *Hydrology for engineers*, McGraw Hill Kogakusha Ltd., Japan.

Groundwater Hydrology

Course Title: Groundwater Hydrology **Full Marks: 35**
Course No.: GEO 633b **Pass Marks: 14**
Nature of the course: Theory **Year: Second**

Course Description: The course on groundwater hydrology provides the essentials for the exploration, drilling, development, and management techniques of groundwater.

General Objective: To give in-depth knowledge and understanding of groundwater hydrology.
Specific Objective: To provide the students with in-depth knowledge and practical skills of

- Groundwater exploration,
- Well hydraulics, well design, well drilling, and development techniques, and
- Groundwater monitoring.

Course Contents:
Groundwater exploration :Hydrogeologic reports. Maps. Aerial photographs. Formation sampling. Geophysical exploration methods. Analysis of aquifers using pumping test data.
Well hydraulics : Definition of terms. Nature of converging flow. Cone depression. Equilibrium well equations. Nonequilibrium well equation. Modified nonequilibrium equation. Hydrogeological conditions that affect time-drawdown graphs. Calculating drawdown for intermittent pumping situations. Distance-drawdown graphs Well interference. Well efficiency. Radius of influence. Recharge and boundary conditions. Combined use of semilog graphs. Effect of partial penetration. Water- level recovery data. Theis nonequilibrium well equation. Other methods of aquifer analysis.
Well drilling methods : Cable tool method. California stovepipe method. Direct rotary drilling. Drilling fluids. Reverse circulation rotary drilling Air drilling systems. In-verse drilling. Dual-wall reverse circulation rotary method. Drill-through casing driver. Jet drilling. Hydraulic-percussion method. Boring with earth augers. Driven wells. Drilling procedures when boulders are encountered. Fishing tools. Grouting and sealing well casing. Plumbness and alignment.
Drilling fluids : Types of drilling fluids. Functions of a drilling fluid. Properties of water-based drilling fluids. Treatment of mix water for drilling fluids. Mixing additives into water-base systems. Air drilling. Drilling fluid additives. Guidelines for solving specific drilling fluid problems. Typical drilling problem.
Well screens and method of sediment-size analysis : Continuous-slot screen. Other types of well screens. Sediment-size analysis.
Water well design : Casing diameter. Casing materials. Well depth. Well screen length. Well screen slot openings. Pressure-relief screens. Formation stabilizer. Well screen diameter. Open area. Entrance velocity. Screen transmitting

capacity. Selection of material. Design of domestic wells. Design for sanitary protection. Special well designs.

Installation and removal of well screens : Pull-back method. Open-hole methods for screen installation. Filter packed wells. Installation of plastic screens. Bail-down procedure. Wash-down method. Jetting method. Installing well points. Removing well screens.

Development of water wells : Well development. Factors that affect development. Well development methods. A comparison of three development methods. Use of polyphosphates in development. Development of rock wells. Allowable sediment concentration in well water. Aquifer development techniques.

Collection and analysis of pumping test data : Conducting a pumping test. Measuring drawdown in wells. Well efficiency. Step-drawdown tests. Problems of pumping test analysis.

Water well pumps

Variable displacement pumps. Positive displacement pumps. Pumps used to ciculate drilling fluid. Air-lift pumping. Pump selection. Water storage.

Water-quality protection for wells and nearby groundwater resources : Choosing a well site. Predicting the pollution potential at a drilling site. Well design. Disinfection procedures required to maintain a sanitary well during drilling. Disinfecting wells and piping. Sealing and wellhead. Horizontal suction lines. Pitless adaptors. Sealing abandoned wells.

Well and pump maintenance and rehabilitation : Major causes of deteriorating well performance. Well failure caused by incrustation. Well failure caused by iron bacteria. Well failure caused by physical plugging of screen and surrounding formation. Importance of screen design on rehabilitation. Well failure from corrosion. Pump maintenance.

Groundwater law. Water well specifications. Contract problems.

Groundwater monitoring technology : Major federal legislation pertaining to groundwater quality and monitoring procedures. Groundwater contamination sources. Effect of aquifer characteristics on the spread of groundwater contamination. Delineating contaminant plumes. Monitoring contaminant movement (transport). Locating monitoring wells. Personnel safety at monitoring sites. Design of monitoring wells. Sampling monitoring wells. The task of groundwater protection. Aquifer restoration.

Alternative uses for wells and well screens : Dewatering. Well-point systems used for water supply. Infiltration galleries. Collector wells. Injection wells. Pressure-relief wells. Wells for heat pumps. Surface-water withdrawal.

Water treatment : Components of water treatment and waste treatment systems. Treatment technologies appropriate for meeting drinking water regulations. Point-of-use water treatment systems.

Wise use of groundwater

Estimating groundwater use, recharge, and volume in storage. Impact of droughts on groundwater supply and use. Managing groundwater supplies.

Evaluation of mineral deposits. The geological service of mining enterprises.

Course Title: Groundwater Hydrology **Full Marks: 15**
Course No.: GEO 637 **Pass Marks: 06**
Nature of the course: Practicals **Year: Second**

Course Contents:
Sieve analysis and grain size distribution- Calculation of Hydraulic Conductivity by Hazen method.
Thiessen polygon diagrams and calculation of average depth of rainfall.
Preparation of flow nets and determination of groundwater flow directions. Problems related to flow nets.
Problems related to aquifer characteristics and well hydraulics: total head, pressure head and elevation head of the wells. Groundwater storage, discharge, recharge, velocity, radius of influence, drawdown at distances. Reynolds number and Darcy's law application.
Processing the pumping test data and calculation of storage coefficient, transmissivity, hydraulic conductivity from pumping test data using Theiss method. Waltons method. Jacobs method and recovery method.
Well parameters like specific capacity, well loss formation loss, well efficiency.
Water chemistry and various methods of data presentation.
Preparation of hydrogeological maps.
Groundwater modelling.

Textbooks:

1. Todd, K.D.,(1980), *Groundwater Hydrology (2nd ed.),* John Wiley &Sons Inc.,New York
2. Driscoll, F.G.,(1989), *Groundwater and Wells.,* Johnson Filtration Systems Inc.,Minnesita
3. Fetter, C.W.,(1990), *Applied Hydrology(2nd ed.)*, CBS Publishers India

Reference Books:

1. Lloyd, J.W. (1981), *Groundwater Resources Evaluation*
2. Jones, G.P. and Rushton, K.R. (1981) *Pumping -test analysis*. Groundwater Resources Evaluation(Lloyd)
3. Raghunath, H.M. (1992), *Groundwater (2nd ed*) Wiley Eastern Limited, New Delhi, India.
4. Garg, S.P. (1982), *Groundwater and Tubewells (2nd ed.)* Oxford and IBH publishing Co. Ltd. New Delhi.

Remote Sensing and Geoinformatics

Course Title: Remote Sensing and Geoinformatics **Full Marks: 35**
Course No.: GEO 634a **Pass Marks: 14**
Nature of the course: Theory **Year: Second**

Course Description: The course on remote sensing provides the essentials of the photogrammetry and digital impage processing.

General Objective: To give in-depth knowledge and understanding of remotely sensed data.
Specific Objective: To provide the students with in-depth knowledge and practical skills of

- Aerial photo interpretation,
- Satellite imagery interpretation, and
- Their use in engineering geology.

Course Contents:
Concepts and foundations of remote sensing : Introduction. Energy source and readiaation principles. Energy interactions in the atmosphere. Energy interactions with earth surface features. Data acquisition and interpretation. Reference data. An ideal remote sensing system. Characteirstics of real remote sensing systems. Successful application of remote sensing. Land and geographic information systems.
Elements of photographic systems : Introduction. Early history of aerial photography. Basic negative-to-positive photographic sequence. Processing black and white films. Film exposure. Film density and characteristic curves. Spectral sensitivity of black and white films. Color film. Processing color films. Color infrared film. Filters. Aerial cameras Electronic imaging. Video recording. Basic geometric characteristics of aerial photographs. Photographic resolution.
Introduction to airphoto interpretation : Inrroduction. Fundamentals of airphoto interpretaion. Basic photo interpretaion equipment. Land use/land cover mapping. Geologic and soil mapping. Agricultural applications. Forestry applicarions. Rangeland applications. Water resource applications. Urban and regional planning applications. Wetland mapping. Wildlife ecology applications. Archaeological applications. Environmental assessment. Principles of landform identification and evaluation. Bedrock landforms. Aeolian landforms. Glacial Landforms. Fluvial landforms. Organic landforms.
Photogrammetry : Introduction. Geometric elements of a vertical photograph. Determining horizontal ground lengths, directions, and angles from photocoordinates. Relief displacement of vertical features. Image parallax. Parallax. Parallax measurement. Ground control for Aerial photography. Use of ground control in determining the flying height and ari base of aerial photographs. Stereoscope plotting instruments. Orthophotos. Flight planning. Soft copy photogrammetry.

Multispectral, thermal, and hyperspectral scanning : Introduction. Across-track multispecral scanning. Along-track multispecral scanning. Across-track thermal scanning. Thermal radiation principles. Interpreting thermal scanner inagery. Geometric characteristics of across-track scanners. Temperature mapping with thermal scanner data. FLIR systems. Imaging spectrometry.

Earth resource satellites operating in the optical spectrum : Introduction. Early history of space imaging. Landsat satellite program overview. Orbit characteristics of Landsat-1, -2, and -3, Sensors onboard Landsat-1, -2, and -3, Landsat MSS image interpretation. Orbit characteristics of Landsat-4 and -5. Sensors Onboard Landsat-4 and -5. Landsat TM image interpretation. Landsat-6 planned mission. Landsat ETM image simulation. Landsat-7. SPOT Satellite Program. Orbit characteristics of SPOT-1, -2, and -3, SPOT HRV image interpretation. SPOT -4 and -5, Meteorological satellites. Earth observing system.

Digital image processing : Introduction. Image rectification and restoration. Image enhancement. Contrast manipulation. Spatial feature minipulation. Multi-image manipulation. Image classification. Supervised classification. The classification stage. The training stage. Unsupervised classification. The output stage. Postclassification smoothing. Classification accuracy assessment. Data merging and GIS integration. Biophysical Modeling. Scale effects.

Microwave sensing : Introduction. Rader development. SLAR system operation. Spatial Resolution of SLAR Systems. Geometric characteristics of SLAR imagery. Transmission characteristics of radar signals. Earth surface feature characteristics influencing radar returns. Interpretation of SLAR imagery. Experimental radar remote sensing from space. Almaz-1, ERS satellite program sensors onboard ERS-1, ERS-1 AMI Image interpretation. JERS-1, Radarsat. Spaceborne radar system summary. Radar remote sensing venus. Elements of passive microwave sensing. Passive microwave sensors. Applications of passive microwave sensing. Lidar.

GIS techniques : Introduction to GIS. Databases. Map coordinate systems and map projections. Conceptual models, data models and data structures. Data structures cnt. topology. Data import and export. Analysis-overlaying vectors. Map algebra. Modelling. Implementaing GIS in an organisation. Acquisition and enhancement of digital images. Radiometric correction and geometric transformation. Classification mothods. Evaluation of classification-integration of GIS and RS. Introduction to raster and vector based GIS programs.

Course Title: Remote Sensing and Geoinformatics **Full Marks: 15**
Course No.: GEO 638 **Pass Marks: 06**
Nature of the course: Practicals **Year: Second**

Practicals:

Film exposure. Film density and characteristic curves. Spectral sensitivity of black and white films. Color film. Processing colour films. Colour infrared film. Basic geometric characteristics of aerial photographs. Photographic resolution. Geometric elements of a vertical photograph. Determining horizontal ground lengths, directions, and angles from photo co-ordinates. Relief displacement of vertical features. Image parallax. Parallax. Parallaxmeasurement. Ground control for Aerial photography. Use of ground control in determining the flying height and ari base of aerial photographs. Stereoscope plotting instruments. Orthophotos. Flight planning. Soft copy photogrammetry.

Land use/land cover mapping. Geologic and soil mapping.

Interpreting thermal scanner imagery. Image rectification and restoration. Image enhancement. Contrast manipulation. Spatial feature manipulation. Multi-image manipulation. Image classification. Supervised classification. The classification stage.

Introduction to raster and vector based GIS programmes.

Textbooks:

1. Miller V. C. and Miller C. F. (1961) : Photogeology, Mc Graw-Hill, New York,
2. Pandey S. N. T. (1987) : Principles and Applications of photogeology, Wiley Eastern New Delhi.
3. Marcolongo B. and Franco M. (1997) : Photogeology : Remote Sensing Applications in Earth Science, Oxford and IBH Delhi, 195 p.

References :

1. Lillesand T. M. and Kiefer R. W. (1994) : Remote Sensing and Image Interpretation, John Wiley and Sons, Inc, New York.

Field Work

Course Title: Field Work
Course No.: GEO 634b
Nature of the course:Practical

Full Marks: 50
Pass Marks: 20
Year: Second

Course Description: Field work is carried out to provide the field knowledge of engineering works and skills of observation, data recording, sampling, description, analysis, interpretation of geological features along road alignments, tunnels and dams.

General Objective: To give the knowledge, techniques and skill of engineering geological and geographical mapping in the field.
Specific Objective: To provide the students with the techniques of, Mapping of rock outcrop for engineering purpose, interpretation of rocks texture and structure paleocurrent, sedimentary structure, foldsand faults and Preperation of engineering geological maps, cross-sections and profiles.

Course Contents:
Location: The fieldwork will be carried out in the nothren part of Kathmandu (Melamchi area). The location may vary depending upon the criteria set by the Department
Introduction: Study of topographical and geological maps of the area, study of main engineering geological, geotechnical and geological techniques of field of rockand soils.
Serveying: Preperation of root maps and engineering geologicalmaps along various routs. Mapping of rocks, soils, instabilities and other features (folds, faults, joints, foliation,bedding, slope angle, groundwater conditions, surface runoff). Preperation of engineering geological maps in 1:5,000 and 1:2,000 scales.
Interpretation: Inerpretation of the data on the basis ofcollected informations. Use of stereographic projection in rockside interpretation. Interpretation of geophysical data.
Field report: The field report includes chapter on regional setting, previous works, lothology, stratigraphy and environment of deposition, structural interpretation of the area and geological maps and cross-sections. Apart from the report, the students will collect relivant rocks and fossil samples. The students prepare drawings, maps, and field note books contanning all the relevant informations.

Textbooks:

1. Lee I.K., White W. and Ingles O. G. (1983) : Geotechnical Engineering, Pitman, 507 p.
2. Bell F. G. 1983 Fundamentals of Engineering Geology.
3. Hock and Bray J. (1977) : Rock Slope Engineering.

References :

1. Journal of Nepal Geological Society (various Issues)
2. Bulletin of Department of Geology (various Issues)

Course Title: dissertation	**Full Marks: 100**
Course No.: GEO 639	**Pass Marks: 40**
Nature of the course: Practical	**Year: Second**