TRIBHUVAN UNIVERSITY
INSTITUTE OF SCIENCE AND TECHNOLOGY

CURRICULUM ON
MASTER OF SCIENCE IN ENGINEERING GEOLOGY
(M.Sc. IN ENGINEERING GEOLOGY)

2077 BS (2020 AD)

CURRICULUM ON
MASTER OF SCIENCE IN ENGINEERING GEOLOGY

INTRODUCTION

Tribhuvan University is the oldest national university of Nepal which provides courses in a large number of disciplines. In view of the need of trained manpower in the field of Engineering Geology in the country, and having a wide scope internationally, the M. Sc. Engineering Geology Program has been established under TU. Presently engineering geology has a wide application in areas of engineering, primarily in investigation of geological conditions that may affect the design, construction, operation and maintenance of large scale engineering projects such as dams, tunnels, highways, water resources development, and natural hazard mitigation and environmental management. The aim of this course is to produce required manpower who can competently work in the field of Engineering Geology and capable of fulfilling the present demand of the industry and academia.

OBJECTIVES

The objectives of the present curriculum are to

Produce high-level and competent manpower in the field of engineering geology as per the need of the country and international demand.

Provide advanced and latest knowledge to students with sufficient geological, geotechnical and engineering base required for the practical application and research in engineering geology profession.

Involve students in research activities to create broad research and analytical skills, and provide practical experience in the field of engineering geology. Create research facilities and environment for collaborations and cooperation with universities and institutions internationally.

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 other equivalent universities or institutions shall be considered eligible for admission to the M.Sc. course in Engineering Geology. They should have also attended the prescribed geological field training at the B.Sc. level.

Admission Criteria

The applicants will have to appear in an entrance examination of two hours' duration conduced by the Dean's Office of IOST. The 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 applications will be prepared based on the percentage of marks in their B.Sc. Examination (20%) and marks obtained by them in the Entrance examination (80%). Admission of the students will be based strictly on the merit list and the enrolment capacity of the concerned institution.

Medium of Instruction: English

Duration of the program. Four semesters completed in two academic years. A student should complete the course within 5 years.

Hours of Instruction and Credit Calculation

Working days: 90 days per semester
Semester: 4
Total credits: 70
Full marks: 1750
Theory:
One credit = 15 lecture hours and 25 marks
One theory paper of one credit will have one hour of lecture per week.

Practical
One credit = 45 labwork hours and 25 marks
One practical paper of 1 credit will have 3 hours

Field work
One credit = 56 field work/lecture hours and 25 marks.
Field work will have 56 lectures/work hours per week.

Dissertation
The dissertation carries four credits. The student shall have to prepare a dissertation in the 4th semester. The dissertation will ordinarily include from 4 to 6 weeks of fieldwork.

Evaluation
Theory Paper
Forty percent (40%) marks as internal assessment and it is assessed by concerned teacher on the basis of assignments, attendance, seminar and internal examination. 60% mark is allocated for Final examination.

Practical:
The practical work is evaluated separately (100%).

Dissertation:
The dissertation will be submitted to the Research Committee of the respective department. The dissertation will be examined by the research committee according to the rules and regulations of the Committee, the date for the defense of the dissertation will be fixed by the research committee of the respective department of the Geology, Tribhuvan University.

Seminar
All students should present at least one paper allocated to him on the regular seminar of the Program and attain all seminars given by other students. The students are evaluated by assessing their presentation and attendance in seminars given by other candidates.

Grading
Students must pass all compulsory papers separately. The pass marks for both theory and practical is 50%. The performance of student shall be made on a four point scale ranging from 0 to 4 grades. A student must secure a minimum Grade Point Average (GPA) of 2.7 or Grade B minus (B) in each course. The absolute grading scale will be as follows:

Grade	CGPA	Percentage Equivalent	Performance Remarks
A	4.0	90 and above	Distinction
A-	3.7	80-89.9	Very good
B+	3.3	70-79.9	First Division
B	3	60-69.9	Second Division
B-	2.7	50-59.9	Pass in Individual Subject
F	0	below 50	Fail

Certificate
The successful candidates who have passed all the examinations in theoretical and practical subjects, fieldwork, project works, seminar and dissertation work, will obtain a certificate of Master of Science in Engineering Geology from Tribhuvan University.

COURSE STRUCTURE

The first semester of master's degree program in Engineering Geology covers the following core study areas and appendant modules:

SEMESTER I

COURSE CODE	COURSE TITLE	CREDITS	MARKS (1 Cr. 25 MARKS)
EGE521	Igneous and Metamorphic Petrology	2	50
EGE522	Sedimentology and Sedimentary Petrology	2	50
EGE523	Structural Geology	2	50
EGE524	Engineering Geomorphology	2	50
EGE525	Geology of the Himalaya	2	50
EGE526	Remote Sensing and GIS	2	50
EGE527	Practical I: Igneous and Metamorphic Petrology	1	25
EGE528	Practical II: Sedimentology and Sedimentary Petrology	1	25
EGE529	Practical III: Structural Geology and Geology of Himalaya	1	25
EGE530	Practical IV: Engineering Geomorphology	1	25
EGE531	Practical V: Remote Sensing and GIS	1	25
EGE532	Field work (**15 days**)	2	50
	Total:- 12 Theory + 5 Practicals + 2 Field work	**19**	**475**

SEMESTER II

COURSE CODE	COURSE TITLE	CREDITS	MARKS (1 Cr. 25 MARKS)
EGE561	Soil Mechanics and foundation engineering	3	75
EGE562	Rock Mechanics	2	50
EGE563	Applied Geophysics	2	50
EGE564	Hydrogeology	2	50
EGE565	Site investigation and Exploration	2	50
EGE566	Advanced mathematics and Geo-statistics	2	50
EGE567	Practical I: Soil Mechanics and foundation engineering	1	25
EGE568	Practical II: Rock Mechanics	1	25
EGE569	Practical III: Applied Geophysics	1	25
EGE570	Practical IV: Hydrogeology	1	25
EGE571	Field Works (15 days)	2	50
	Total:- 14 Theory + 4 Practical + 2 Field work	**19**	**475**

SEMESTER III

COURSE CODE	COURSE TITLE	CREDITS	MARKS (1 Cr. 25 MARKS)
EGE621	Slope stability and Landslide Engineering	3	75
EGE622	Highway and Tunnel Engineering	3	75
EGE623	Construction Material Engineering	2	50
EGE624	Geotechnical Earthquake Engineering	2	50
EGE625	Engineering Hydrology	2	50
EGE626	Hydropower Engineering	2	50
EGE627	Numerical Modeling	2	50
EGE628	Practical I: Engineering drawing and Surveying	1	25
EGE629	Practical II: Construction Material Engineering	1	25
EGE630	Practical III: Slope Stability and Landslide engineering	1	25
EGE631	Practical IV: Geotechnical Earthquake Engineering	1	25
EGE632	Practical IV: Engineering Hydrology	1	25
EGE633	Field works (15 days)	2	50
	Total:- 16 Theory + 5 Practical + 2 Field work	**23**	**575**

SEMESTER IV

COURSE CODE	COURSE TITLE	CREDITS	MARKS (1 Cr. 25 MARKS)
EGE661	Engineering Project Management	2	50
EGE662	Seminar (Proposal and paper writing)	1	25
EGE663	Dissertation	4	100
Elective (Any One)			
EGE664	Climate Change and Disaster Risk Management	2	50
EGE665	Landfill Engineering and Solid Waste Management		50
EGE666	Environmental Assessment of Engineering Project		50
	Total:- 4 Theory + 1 Seminar + 4 Thesis	**9**	**225**

SEMESTER I

SEMESTER: I

Course Title: Igneous and Metamorphic Petrology Full Marks: 50
Course No.: EGE521 Pass Marks: 25
Nature of the course: Theory 2 Credits (30 hrs)

COURSE DESCRIPTION: This course provides the students with the concepts of igneous and metamorphic petrology. It deals with the igneous and metamorphic rocks, rock forming systems, rock properties and their engineering significance, classification, field relations, plate tectonic rock association in space and time and engineering implications of petrography studies of minerals and rocks.

GENERAL OBJECTIVES: To provide in-depth understanding of igneous and metamorphic rocks and their engineering significance.
SPECIFIC OBJECTIVES: To provide the students with in-depth knowledge and practical skills of
-Magmatism and metamorphism,
-Geodynamic relations of formation of different types of rocks,
-Modern methods of study and analysis of igneous and metamorphic rocks and
-Engineering significance of rock forming minerals as well as igneous and metamorphic rocks.

COURSE CONTENTS

Title	**Content**	**Teaching hours**
Igneous Petrology (1 Cr.)		
Fundamentals of igneous petrology	The Earth's interior, differentiation of the earth, pressure and temperature variation with depth, Igneous rock forming minerals mafic minerals, felsic minerals, accessory and secondary minerals, rock forming processes in relation to plate tectonics.	**2**
Classification and nomenclature of igneous rocks	Classification of igneous rocks: Streikeisen's classification of igneous rocks; mineral composition and fabrics of acidic rocks, intermediate rocks, basic rocks and ultra-basic rocks, methods of identification in the field, igneous structures and field relationship, textures of igneous rocks: primary and secondary textures, introduction to petro-chemistry, chemical classification, methodology of systematic study of rocks, variation diagram.	**3**
Thermodynamics in geologic processes	First law and Second law of thermodynamics, Gibb's Free Energy for closed and open systems, chemical potential, Clausius-Clapeyron equation, phase rule, **f**ormation of crystals in a liquid, crystallization in binary & ternary systems.	**3**
Generation, diversification and ascent of magma	Magma generation in the earth in relation to plate tectonics,Partial melting, Magmatic differentiation, magma mixing, Assimilation;Granitoid rocks: Petrography of granitoids, Granitoid Geochemistry, Crustal melting, Granitoid classification, Geochemical discrimination of tectonic granitoids, The role of the mantle in granitoid genesis, Origin of the continental crust.	**3**
Chemical petrology	Trace Elements and Isotopes: Element abundance and distribution, The Rare Earth Elements, spider diagrams, application of trace elements to igneous systems, geochemical criteria for discriminating between tectonic environments (Discrimination diagram) and isotopes (stable, radioactive and radiogenic isotopes).	**2**

Engineering significance of igneous rocks	Application of igneous petrography to engineering problems, Engineering significance of rock-forming minerals and rocks in terms of texture, structure and genesis; geochemistry of epigenesis, occurrence of chemical elements in supergene zone, natural media of the supergene zone, classification of epigenetic processes (supergene processes) and weathering.	**2**
Metamorphic Petrology (1 Cr.)		
Introduction to metamorphism	Limits of metamorphism, metamorphic agents and changes, types of metamorphism, progressive nature of metamorphism, types of protolith, P-T-t paths, grades, zones and facies, some case studies of different types of metamorphisms.	**2**
Classification and nomenclature of metamorphic rocks	Classification of Metamorphic Rocks: foliated and lineated rocks, non-foliated and non-lineated rocks, specific metamorphic rock types, additional modifying terms, high-strained rocks, field relations of metamorphic bodies, classification of three types of metamorphism based on P/T ratio, paired metamorphic belts, metamorphic rocks of different grades, petrography of common metamorphic rocks of the Himalayas	**3**
Petrogenesis and petrofabric of metamorphic rocks	Processes of deformation, recovery and recrystallization, textures, high-strained textures, microstructures and shear sense indicators, mechanism of tectonite development, gneissose structures and layers, mineral growth, analysis of poly-deformed and poly-metamorphosed rocks, crystallographically controlled inclusions, replacement textures and reaction rims; textural geo-chronology,metamorphic reactions, petrogenetic grids, compositional variations and geothermo-barometry, structural petrology.	**4**
Stable mineral assemblages and metamorphic reactions	Phase rule in metamorphic system, common chemographic diagrams and common metamorphic reactions	**2**
Metamorphism of different rocks	Metamorphism of ultramafic and mafic rocks, metamorphism of pelitic and calcareous rocks.	**2**
Engineering Significance of Metamorphic Rocks	Engineering significance ofmetamorphic minerals/index minerals and rocks in terms of texture, structure and nature of protolith; geochemistry of epigenesis, variation in strength with respect todeformation, metamorphic structures, micro-cracks and weathering.	**2**

Textbooks

1. Winter, J. D. (2012). Principles of Igneous and Metamorphic Petrology (secondedition),PHI Learning Private Limited, New Delhi-110001, 702p (original U.S. edition).
2. Best M. G. (1986): Igneous and Metamorphic Petrology, CBS Delhi, 639. p.
3. Perkins, D. (2003). Mineralogy (2nd edition), Pearson Education, Delhi, 483 p.
4. Peral'man, A.I., Kohanowski, N.N. andFairbridge, R.W. (1965), Geochemistry of Epigenesis. Nedra Press, Moscow, 266 p.
5. F. H. Hatch, A.K. Wells& M.K. Wells. Petrology of the igneous rocks. CBS Delhi, 551. p.

Reference Books

1. Miyashiro A. (1994): Metamorphic Petrology, IJCL, 404 p.
2. Hyndman D.W. (1985): Petrology of Igneous and Metamorphic Rocks, McGraw Hill, 786 p.
3. McBirney A. R. (1993): Igneous Petrology, Jones and Bartlett Publishers, Inc., 508 p.
4. Yardley B. W. D. (1990): An Introduction to Metamorphic Petrology, ELBS, 248 p.
5. Hall, A. (1988): Igneous Petrology, ELBS, 573 p.
6. Phillpots, A. R. (1994): Principles of Igneous and Metamorphic Petrology Prentice-Hall of India Pvt.Ltd., 498p.
7. Thorpe, R. S. and Brown, G. C. (1995): The Field Description of Igneous Rocks, John Weiley& Sons, 154 p.
8. Carmichael, I. S. E., Turner, F. J., and Verhoogen, J. (1974): Igneous Petrology, McGraw Hill Inc., 739 p.
9. Hutchinson (1974): Laboratory Methods in Petrography, John Wiley and Sons, New York, 527p.
10. Winkler H. G. F. (1987): Petrogenesis of Metamorphic Rocks. 5th edition, Narosa Publishing House Delhi, 348p.

SEMESTER: I

Course Title: Sedimentology and Sedimentary Petrology Full Marks: 50
Course No.: EGE522 Pass Marks: 25
Nature of the course: Theory 2 Credits (30 hours)

COURSE DESCRIPTION

This course is aimed to introduce the concepts of sedimentology and sedimentary petrology. Sedimentology provides knowledge on sediment properties, sediment formation and erosion, sediment transport, and sedimentation processes. Sedimentary petrology, it deals with the sedimentary rocks focusing on their texture, structure, mineral composition, classification, origin, diagenesis and environments of deposition.

OBJECTIVES

General Objective: To provide in-depth understanding of sediment and sedimentary rocks, their properties, composition, classification, and processes of formation, transportation, sedimentation, and diagenesis.

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

- Sediment properties,
- Description, classification and nomenclature of sediments and sedimentary rocks.
- Sedimentary processes of formation, transportation and sedimentation,

COURSE CONTENTS

SEDIMENTOLOGY (1 credit)

Types of sedimentary particles: Solid Breakdown products of older deposits: Terrigenous particles: Inorganic terrigenous sediments and carbonaceous organic debris. Particles that are not solid breakdown products of older deposits: pyroclastic particles and authigenic particles.-**2 hours**

Classification and Nomenclature of Sediments: Siliciclastic Sediments: Gravel-sand-clay mixture, Sand-silt-clay mixture and Classification and nomenclature of Carbonate Sediments.-**1 hour**

Properties of Sediments: Mass density and specific weight of solid particles. Grain Size: grain size classification, fall diameter, nominal diameter, gradation coefficients, Grain size distribution plots. Probability plots. Graphic measures of size distribution: graphic mean. inclusive graphic standard deviation, inclusive graphic skewness, and graphic kurtosis. Significance of grain size analysis. Shape factor, form, sphericity and roundness. Sorting, packing, orientation of particles, and porosity, Sediment Suspension: volumetric sediment concentration, specific weight of mixture, Dynamic viscosity of a Newtonian mixture, Kinematic viscosity of a Newtonian mixture.-**3 hours**

Sediment formation and erosion: *Physical and chemical weathering*: Freeze and thaw, frost wedging, frost heaving, exfoliation, and slaking. Hydrolysis, hydration, oxidation, solution. Weathering of Rock forming minerals. Factors controlling rates of weathering, Goldich's Stability of sequence of rock forming minerals, stability of common minerals under weathering, geochemical differentiation of elements from weathering of rocks. Weathering and soil formation.

Concept of Erosivity and erodibility: Mechanism of erosion by fluid. Soil erosion: surface erosion: Interrill and rill erosion. Channel erosion: gully erosion and stream channel and bank erosion. Gravitational erosion: Gravity Displacement Processes: gravity shearing, creep, debris slide, debris avalanche, and sediment gravity flows: grain flow, fluidized sediment flow, mud flow and debris flow, and turbidity flow. *Sediment Yields*: statistical and deterministic models. Sediment Delivery Ratio: SDR versus drainage area. Quantifying gully and river erosion. sediment rating curves. Stream bank erosion susceptibility index. Annandale's Erodibility Index Method. -**3 hours**

Sediment transport:
Stream morpho-hydrologic parameters and Flow Velocity-Discharge Measurement: Stream cross-section and profile patterns. Stream classification. Stream planform parameters. Morpho-hydrologic parameters. Flow velocity-discharge measurements: Vertical Velocity Distribution, Velocity Profile Measurement. Discharge measurement: Area-velocity method. Mass flux calculation.-**1 hour**

Resistance to Flow: State of flow. Effect of fluid viscosity: laminar flow and turbulent flow, Reynolds Number, Drag Coefficient. Effect of gravity: Froude Number. Chézy Equation, Manning Equation, Darcy-Weisbach Equation, Hydraulic flow-resistance factors; Estimating Total Roughness using Cowan's Method.-**1 hour**

Sediment load: Modes of transport, Incipient motion: velocity criteria: Hjulström Approach. Shear stress criteria: Shields Diagram and criterion. Stream power vs. erodibility index criterion of incipience. Boundary conditions. *Bedload transport*: deterministic, probabilistic and stream power approaches. *Suspended load transport*: Sediment Concentration Profile. Rouse's equation. Total Sediment Load. Sediment Transport Capacity.-**1 hour**

Sediment Deposition and sediment characteristics: *Lake or Reservoir*: Settling Velocity of mud and coarse grains, Flocculation. Subaqueous gravity displacement sedimentation from turbidity currents.
Alluvial Fan: Debris flow fan and stream flow fan. *Braided Rivers*: channel and bar deposits. Meandering Rivers: In-channel, bank and flood plain deposits; *Glacial Environment*: valley glaciers and continental glaciers. Process of glacial movements. Glacial ice contact deposits. Proglacial deposits. Periglacial processes and deposits. Sediment characteristics in desertic environment: Bare rock surfaces, alluvial fans, intermittent stream deposits, eolian deposits, and inland sabkha and playa deposits.-**3 hours**

SEDIMENTARY PETROLOGY (1 credit)
Siliciclastic rocks
Mudrocks: Texture and structures, mineral composition, colour, classification of mudrocks. Shales: residual clays, common shales, red shales and mudstones, black shales, siliceous shales, calcareous shales and marls, mischellaneous shales, siltstone and loess. Origin and distribution of clay minerals In modern sediment. Diagenesis of clay minerals and mudrocks. mud sediments in depositional environments. -**3 hours**

Sandstones: Fabric of sandsotnes. Structures. Mineralogy of sandstones. Classification of sandstones. Origin of sandstones: quartz arenites, arkoses, litharenites, and greywackes. Sandstone Diagenesis: compaction, intrastal solution, cementation, and authigenesis. sand sediments in depositional environment.-**3 hours**

Conglomerates and Breccias: Fabric and composition. Structures. Classification of conglomerates. Orthoconglomerates: orthoquartzitic conglomerate, petromictic conglomerate, paraconglomerate, laminated pebbly mudstone, tillite. Diagenesis of conglomerates. Intraformational conglomerates. Breccias: cataclastic breccia, landslide and slump breccia, collapse and solution breccia, pyroclastic breccia and impact breccia. Coarse sediments in depositional environments. -**3 hours**

Carbonate rocks
Limestones: Mineral composition. Textures and structures of limestones. Classification. Grainstones, boundstones, carbonate mudstones, tufa, travertine, marl and calcrete.-**2 hours**

Dolostones: Mineral composition. Textures and structures of dolostones. Classification of dolostones.-**1 hour**

Diagenesis of carbonate rocks: Cementation, solution, neomorphism, and compaction. Marine diagenesis. Meteoric diagenesis. Dolomitization. Dedolmitization. Silicification. Porosities in carbonate rocks.
Carbonates in depositional environments: Non-marine carbonates. Marine carbonates and carbonate platforms. Tidal flat carbonates. Lagoonal carbonates. Reefs and carbonate buildups. Pelagic limestones.

Resedimented deep-water limestones.-**2 hours**

Authigenic rocks

Siliceous sediments: Chert petrology, Bedded cherts, diagenesis and formation of bedded chert. Nodular cherts. Non-marine siliceous sediments and cherts.-**1 hour**

Textbooks

1. Selley, R.C. (2000). Applied Sedimentology. Second Edition, Academic Press, 543p.
2. Freidman, G.M. and Sanders, J.E. (1978). Principles of Sedimentology. John Wiley and Sons, New York, 792p.
3. Collinson, J.D. and Thompson, D.M. (1994). Sedimentary structures, CBS, Delhi, 207p.
4. Tucker, M.E. (1981). Sedimentary petrology: an Introduction. Geoscience Texts, Vol. 3. Blackwell Sci. publications. 252p
5. Pettihohn, F.J. (1975). Sedimentary rocks. Harper and Row, New Yo5rk, 628p.
6. Tamrakar, N.K. (2011). Practical Sedimentology. Bhrikuti Academic Publication, Kathmandu, 232p.
7. Morris, G. L. and Fan, J., (2010). Reservoir Sedimentation Handbook, McGraw-Hill, 805p.
8. Blatt, H. (1992). Sedimentary Petrology, second edition, W.H. Freeman and company, New York, 514p.
9. Selley, R.C. (1973). Ancient sedimentary environments and their subsurface diagenesis. second edition Chapman and Hall, London, 287p.
10. Leeder, M.R. (1982). Sedimentology: process and product, Georg Allen and Unwin, London, 344p.

Reference Books

1. Folk, R.L. (1980). Petrology of Sedimentary rocks. Hemphill Publishing Company. Austin, Texas, 184p.
2. Pettijohn, F. J. Potter, P. E. Siever. R. (1987). Sand and sandstones, 2nd ed., Springer-Verlag; New York, Berlin, Heidelberg, London, Paris, Tokyo, 355p.
3. Lindholm, R. (1999). A practical approach to sedimentology. CBS Publishers & Distributors, Delhi, 176p.
4. Greensmith, J.T. (1978). Petrology of the sedimentary rocks. (sixth Edition). George Allen & UNWIN/Thomos Murby, London, boston, Sydney.
5. Tamrakar, N.K. (2013). Handbook of field geology with reference to the Siwaliks. Central Department of Geology, Tribhuvan University, Kirtipur, Kathmandu, Nepal. 162

SEMESTER I

Course Title: Structural Geology Full Marks: 50
Course No.: EGE523 Pass Marks: 25
Nature of the Course: Theory 2 Credits (30 hours)

COURSE DESCRIPTION

Structural geology deals with the architecture of the earth's crust and its componential parts.
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 and engineering geological significance of Folds, faults, joints. foliation, and lineation. The structural geology course also provides the concepts of stress and strain.

Course Contents

*Introduction:*Introduction of structural geology and structural analysis, scope of structural geology in engineering geology and other branches of geology, primary and secondary structures, descriptive and kinematic analysis, homogeneous and inhomogeneous deformation -**3hours**

Primary structures: Primary sedimentary structures and their significance in structural geology.-**1 hour**

*Secondary structures:*Morphology, geometry, classification and mechanism field identification criteria and engineering geological significances of fold, faults and shear zones, joints, foliation and lineation. Concept of shear zone and mylonite.-**8hours**

Superimposed folding: Concept, environment and mechanism-**2 hours**

Stress: Stress at a point. Stress on a plane. Principal planes of stress.Mohr circle. Types of stresses and Mohr circle configurations for them. Stress in two dimensions.-**3hours**

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. Changes in lengths and orientation of lines in different zones with strain ellipse and corresponding geological structures.-**3 hours**

*Microtectonics:*Concept of microtectonics and its use in structural geology and engineering geology.-**2 hours**

Global Tectonics: Continental drift. Introduction to plate tectonics. Sea floor spreading. Concept of lithospheric plates, Plate margins and triple junctions. Seismic, magmatic, thermal and magnetic properties of different types of plate margins.- **6 hours**

Thin skin tectonics: Introduction, Ramp and flat, Piggy back and overlap sequence, Imbricate fault, duplex, Nappe and klippe, roof thrust and floor thrust, back thrust, blind thrust, out of sequence thrust.-**2 hours**

Textbooks

1. Hobbs, B. E., Means, W. D., and Williams, P. F. (1976): An Outline of Structural Geology,John Wiley and Sons, 571 p.
2. Ramsay, J. G. (1967): Folding and Fracturing of Rocks, McGraw Hill Inc., 568 p.
3. Passchier, C. W. and Trouw R. A. J. (2003): Micro-tectonics, Springer, 253 p.
4. Ramsay, J. G. and Huber, M. I (1983): The Techniques of Modern Structural Geology, Volume 1: Strain Analysis, Academic Press, 307 p.

Reference Books

1. Bayly, B. (1991): Mechanics in Structural Geology, Springer-Verlag, 253 p
2. Johnson A. M. (1977): Styles of Folding, Elsevier Scientific Publishing Company, 406 p.
3. McClay, K. R. (1987): The Mapping of Geological Structures, John Wiley & Sons Inc., 161 p.
4. Ragan D. M. (1985): Structural Geology, An Introduction to Geometrical Techniques,3rd edition,John Wiley & Sons Inc., 393 p.
5. Means W. D. (1985): Stress and Strain Basic concepts of continuum mechanics for geologists, Springer-VerlagNew York, 339 p.
6. Davis G. H. and Reynolds S. J. (1996): Structural Geology of rocks and regions, John Wiley & Sons Inc., 776 p.

SEMESTER I

Course Title: Engineering Geomorphology Full Marks: 50
Course No.: EGE524 Pass Marks: 25
Nature of the Course: Theory 2 Credits (30 hrs)

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.

OBJECTIVES

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

Specific Objectives: 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 to Engineering Geomorphology: Fundamental concept of geomorphology, geomorphic scale, landforms and the nature of modern engineering geomorphology, Landform Change and Engineering Time, Engineering and geomorphology, Techniques in engineering geomorphology -**2 hours**

The earth surface systems: Introduction, types of system, system specification, system change, landscape sensitivity, system dynamics and landscape stability, system complexity, thresholds, models of system behaviour, equilibrium concepts (steady state, dynamic and metastable equilibrium), engineering geomorphological implications.-**2 hours**

Active Tectonic environments and landforms: Stratimorphs and escarpments, escarpments formed in different lithology, sequences uplift and Tectonic subsidence landform, domed structures, Topography of domal structure : types of domal structure, Homoclinal structures, Fold structures and fold mountains, faulted landform: horst, grabens and related form, thrust control landform, Geomorphic expression of faults, Liquefaction and related ground deformation, Engineering implications.-**3 hours**

Climate, Weathering and soil Formation: Climate and Climate variability, role of climate in the development of various landforms, engineering geological implications of climate change, paleogeomorphology (relict, buried, exhumed land form). Climate and flooding, geomorphic significance of weathering, weathering and landscape, weathering and geohazards. Formation of soil Profile, description of major soil group, soil profile, soil erosion and erosion features. Engineering soil types and their behaviour,-**2 hours**

Slope in Karst: Topography & terrain; surface & subsurface landform; features, types of karst terrain, natural tunnel & bridge, Karst geomorphic cycle, hazards, engineering problems in karst terrain.-**2 hours**

Hill slopes geomorphology: Supply of water and sediments, Evolution and classification of hill slopes, hill slope erosion and transport process, mechanisms of slope segment production, slope model and associated

geomorphological processes, Mountain terrain mode, Access and routing, Large scale landslides, Debris flows and torrents, flash flood, landslide dam and GLOF resulting landforms.-**3 hours**

River and drainage basins: Water and sediments load; river morphology; valley morphology and evolution; bank erosion and instability; channel changes on the river; floodplain accretion; erosional and depositional landforms: alluvial fans, valley fill, deltas. River terraces: phases of aggradation and incision, flood, hazard and risk, channel migration and bank erosion, scour. Drainage basins: The basin geomorphic unit, morphometric analysis, morphometric control, drainage basin evolution, drainage basin response. **3 hours**

Glacial environments and landscapes: Glacial erosion and entrainment of sediment, glacier motion (flow), rock debris in glaciers, , erosion by glaciers, till and process of deposition, landforms of glacial deposition. Geomorphological effects of former glacier expansion, identification of glaciomarine, glaciolacustrine and glaciofluvial landscape, glacial lake outburst floods: hazards and mitigation, engineering project on glacial deposits. -2 **hours**

Desert environments and landforms: Climate influence upon geomorphic process, topographic effects of wind erosion, humid tropical landforms, tropical wet-dry landforms, arid and semi-arid landforms, Extreme events and major geomorphological problems in hot wetlands, cold and hot desert landform, Loess Terrain, key engineering geomorphological issues in loess terrain-**2 hours**

Lacustrine and deltic landscapes: Engineering significance of lake margin landforms**,** deltaic setting, forms**,** behaviour, delta hazards-**1 hour**

Application of Geomorphology: Application in site selection for engineering projects (Road, tunnel, bridge, dam, canal); site selection for construction materials; Engineering geological challenges for the development projects in the landforms developed by intrusive and extrusive igneous processes; tectonic and structural landforms in conducting the engineering geological study leading to site suitability; significance of karstified terrain in the occurrence of groundwater and development the area in urban settlement; identification of the landform resulting from large scale landslide and significance of large scale landslide from engineering geological perspective; importance of fluvial processes in occurrence of groundwater with respect to quality and quantity in mountainous and plain area; importance of drainage basin from engineering geological perspective; the glacier process and resulting landform with respect to natural disaster; geomorphological knowledge applied in planning for an urban area; impact of engineering in landscape.-**6 hours**

Geomorphological mapping: Introduction; morphological mapping; Dating techniques in geomorphology, Landform by past earthquakes in site selection part, geomorphological interpretation; geomorphological map scales; modelling processes; uncertainty and expert judgement; investigation techniques; geoinformatics in geomorphological mapping; terrain evaluation process; groundwater evaluation and delineating fractured aquifer zone in hilly terrain-**2 hours**

Textbooks

1. Fookes PG., Lee EM, Griffiths JS. (2007). Engineering Geomorphology Theory and Practice. Whittles Publishing, CRC Press. 269p.
2. Fookes PG, Lee EM, Milligan G (2005). Geomorphology for Engineers. Whittles Publishing, CRC Press. 851p.

Reference books

1. Huggett RJ (2007). Fundamentals of geomorphology, Second Edition. ISBN 0-203-94711-8
2. Burbank DW and Anderson RS (2007). Tectonic Geomorphology, Blackwell Science.
3. McClay KR (1987). The Mapping of Geological Structures, John Wiley and Sons Inc., 161 p.
4. Chorley R, Schumm SA and Sugden DE (1984). Geomorphology, Methuen, 605p.
5. Thornbury DW (2000). Principles of Geomorphology, New age International (P) Limited, Publishers, India. 594 p
6. Burbank DW and Anderson RS.. Tectonic Geomorphology. Blackwell Science. Anbazhagan S, Subramanian SK and Yang X (2011). Geoinformatics in Applied Geomorphology. CRC Press- Taylor & Francis Group. ISBN 13: 978-1-4398-3049-9 (eBook)

SEMESTER: I

Course Title: Geology of the Himalaya Full Marks: 50
Course No.: EGE525 Pass Marks: 25
Nature of the Course: Theory Credit: 2 (30 hrs)

COURSE DESCRIPTION
Himalayan geology covers the stratigraphic, tectonic, structural, magmatic, metamorphic and sedimentary geological aspects of the Himalaya.

OBJECTIVES
General Objectives. To give in-depth knowledge and understanding of the Himalayan geology and associated engineering geological problems.

Specific Objectives. To provide the students in-depth knowledge of

- various stratigraphic sub-divisions of the Himalaya,
- tectonic and structural set up of the Himalaya and its relation with the adjacent regions,
- comparison and correlation of various rock units,
- evolutionary history of the Himalaya,
- Engineering geological problems in the Himalaya.

COURSE CONTENTS
Broader framework. Relation of the Himalaya with other mountain chains of the region. Geology of the Peninsular India with special reference to Delhis, Vindhiyans and Gondwanas. -**1 hour**

Major sub-divisions of the Himalaya. Geomorphic sub-divisions, tectonic sub-divisions. Brief account of the Punjab, Kumaun, Skkim and Bhutan Himalayas.-**1 hour**

Stratigraphic classification in Nepal and adjacent countries. Precambrian successions of Higher and Lesser Himalayas, Paleozoic and Mesozoic successions of Tethys and Lesser Himalayas, Tertiary successions of Lesser and Sub-Himalayan zones. Quaternary successions of 'intermountain basins of Lesser and Higher Himalayas. Correlation of reference sections from Nepal and adjacent countries. Correlation of strartigraphic units of different parts of Nepal with type sections. Isotopic composition and detrital zircon ages of rocks of Nepal Himalaya.-**12 hours**

Major Himalayan structures. Indus–Tsangpo Suture zone, Himalayan syntaxes, Tethyan Himalayan fold-and-thrust belt, Great counter thrust and north-Himalayan antiform, South Tibetan Detachment System (STDS) and other major extensional faults, Main Central Thrust (MCT), southward extension of the MCT (Lesser Himalayan nappes), relationship between MCT-I and MCT-II. Age and slip on the STDS and MCT. Out-of-sequence thrusts and uplifts of the Himalaya. Exhumation history of the Himalaya: Exhumation and foreland sedimentation in the Himalayas. Sedimentation in the foreland basin.-**4 hours**

Metamorphism. Metamorphism in the Higher Himalaya and the MCT zone, low-grade metamorphism in the Lesser and Tethys Himalayas. Inverted metamorphism and its orign. Thermobarometric and geochronological data. Models for Himalayan inverted metamorphism: Kinematic models, thermal models, coupled thermal and mechanical models.-**3 hours**

Magmatic rocks. Precambrian mafic rocks, Permian basalts, Precambrian granitoids, Early Palaeozoic granites. Tertiary granites, Geochemical and isotopic characteristics, geochronological data, petrogenesis and tectonic significance of magmatic rocks. Models for Cenozoic Himalayan anatexis.-**3 hours**

Seismotectonics. Seismotectonics of the Himalaya, seismicity in the Nepal Himalaya, historic earthquakes, recent microseismicity, active faults and neotectonic activity, seismic hazard scenario in the Himalayas.-**2 hours**

Models of evolution of the Himalaya. The original configuration of the Himalaya prior to Cenozoic deformation: single passive continental margin model, separate basin model, accreted terrene model, carboniferous-extension model. Kinematic models for emplacement of the Higher Himalayan crystalline: Wedge extrusion and channel flow, continental subduction, MCT reactivation from Palaeozoic suture, models for the overall evolution of the Himalaya.-**2 hours**

Engineering Geological characteristics of different tectonic zones of the Himalaya that affects the engineering geological behaviour of rocks and slopes in the Himalaya.-**2 hours**

Textbooks

1. Dhital, MR (2015). Geology of the Nepal Himalaya: Regional perspective of the classic collided orogeny. Springer, 498p.
2. Paudel, L. P. (2012). Himalayan Metamorphism: Chemical Prints in Minerals. Geo-Science Innovations P. Ltd., Kathmandu. 108p.
3. Valdiya (2010). Making Of India - Geodynamic Evolution. MacMillan, India
4. Journal of Asian Earth Sciences, Special Issue. Geology of the Nepal Himalaya: Recent Advances. , (1999), Vol 17. Editors: P Le Fort and B.N. Upreti
5. Valdiya, K. S. (1998). Dynamic Himalaya, Universities Press, New Delhi.
6. Valdiya, K. S. (1994). Aspects of Tectonic focus on South Central Asia, Tata McGrawHill.
7. Gansser, A. (1964). Geology of Himalayas, John Wiley and Sons Inc.

Reference books

1. Yin, A. and Harrison, T. M. (eds.) (1996). The Tectonic Evolution of Asia, Cambridge University Press.
2. Journal of Asian Earth Sciences vol 19, Special Issue.
3. Shakleton, R. M.., Dewey, J. F. and Windley, B. F. (eds.) (1988). Tectonic evolution and Himalaya and Tibet, Cambridge University Press.
4. Valdiya, K. S. (1980). Geology of the Kumaon Lesser Himalaya, Wadia Institute of Himalayan Geology.
5. Research articles in various issues of the Journal of Nepal Geological Society, Bulletin of the Department of Geology, TU and international earth science journals.
6. Mascle, G., Pêcher, A., Guillot, S., Rai, S. M. and Gajurel, A. P. (2012). The Himalaya-Tibet Collision. Nepal Geological Society, Nepal, Société Géologique de France and VUIBERT, France.

SEMESTER: I

Course Title: Remote Sensing and GIS Full Marks: 50
Course No.: EGE526 Pass Marks: 25
Nature of the Course: Theory Credit: 2 (30 hrs)

COURSE DESCRIPTION

The course of Remote Sensing and GIS gives the necessary knowledge and skills of remote sensing inputs necessary for site investigation and evaluation for regional and local scale. It also gives knowledge of remote sensing based site selection in the feasibility stage of the project of various infrastructure developments.

OBJECTIVES

General objective

To provide the students in-depth knowledge and practical skills of Remote Sensing and GIS

Specific objectives

- To give knowledge and understanding of remote sensing and GIS for various engineering works
- To prepare remotely sensed data for various geo-hazards evaluation; prepare database and carry out modelling in GIS

REMOTE SENSING FUNDAMENTALS

Introduction: Development in aerial and space photography, Advantages and limitations of photogeological techniques-**2 hours**

Fundamentals: Energy source and radiation principles. Energy interactions in the atmosphere and with earth surface features. Data acquisition and interpretation-**2 hours**

Photo/image interpretation:. Elements of image/photo-interpretations of geotechnical elements such as drainage, soil, landforms and vegetation, convergence of evidence-**2 hours**

AERIAL PHOTOGRAPH

Aerial Photography: Photographic flight mission and layout, Type of aerial photography, Stereoscopy and vertical exaggeration-**2 hours**

Geometric Characteristics of Aerial Photographs: Mosaic construction, Stereoscopic parallax, Basic geometrical relations of scale, Parallax and heights using vertical photographs.- **2 hours**

Instrumentation: Working principle of instruments used for stereo-viewing measuring and plotting, determination of geological data.**-2 hours**

REMOTE SENSING

Application of Remote Sensing: Earth resource satellites operating in the optical spectrum, Multispectral, thermal, and hyperspectral scanning. Across- track and Along-track multispectral scanning. Thermal radiation principles. Interpreting thermal scanner imagery. Temperature mapping with thermal scanner data. - **2 hours**

Digital Image Processing: Image rectification and restoration. Image enhancement. Contrast manipulation. Spatial feature manipulation. Multi-image manipulation. Image classification. Supervised classification. Unsupervised classification. Classification accuracy assessment.- **2 hours**

New Technologies: Space-borne Synthetic Aperture Radar (SAR) interferometry (InSAR); Ground based interferometry (GB-InSAR); LiDAR (Light Detection And Ranging, ground- and air-borne), know also as

Airborne Laser Scanner (ALS) and; Terrestrial Laser Scanner (TLS); Unmanned Aerial Vehicles (UAV) or drones-**2 hours**

GEOGRAPHIC INFORMATION SYSTEM (GIS)

Introduction: Introduction of Geographic Information Systems, Development of GIS; GIS and Maps; applications of GIS-**1 hour**

Coordinate Systems and Map projections: Introduction, geometric earth models, Geodetic datum, requirement of map projection, properties of map projection, projection surfaces and projection family, Projection systems and, Projection system followed by Department of Survey (GoN) -**2 hours**

Data input in GIS: Input of spatial data, Modes of data input, Rasterization and vectorization, Map preparation and the digitizing, Remote Sensing: Special Raster Data Input, Integrating different data sources, External Databases-**2 hours**

Data storage and editing: Storage of GIS database, editing, data error and error propagation -**2 hours**

Spatial analysis: Conceptual framework, spatial data models, Geoprocessing, Spatial analysis (Geo spatial and Spatial Analyst), 3D Analyst, raster and vector-based GIS analysis. -**3 hours**

Global positioning system (GPS): GPS system, calculating a position, receiver outputs, accuracy and availability-**2 hours**

Textbooks

3. Miller V. C. and Miller C. F. (1961). Photogeology, Mc Graw-Hill, New York,
4. Pandey S. N. T. (1987). Principles and Applications of photogeology, Wiley Eastern New Delhi.
5. Marcolongo B. and Franco M. (1997). Photogeology: Remote Sensing Applications in Earth Science, Oxford and IBH Delhi, 195 p.
6. Peter A. Burrough and Rachael A. McDonnell (2004). Principles of Geographical Information Systems, Oxford University Press, 333p.

Reference books

1. Lillesand T. M. and Kiefer R. W. (1994). Remote Sensing and Image Interpretation, John Wiley and Sons, mc, New York.
2. Albert, CTL and Yeung, KW (2002). Concepts and Techniques of Geographical Information Systems, Prentice Hall.

SEMESTER I

Course Title: Practical I: Igneous and Metamorphic Petrology Full Marks: 25
Course No.: EGE527 Pass Marks: 12.5
Nature of the course: Practical Credit: 1 (45 hours)

COURSE DESCRIPTION
The students will study igneous and metamorphic rocks in hand specimen and thin-section.

OBJECTIVES
General Objectives. To provide students with the knowledge and skills of rocks study, its description and interpretation in hand specimens and polarizing microscope and sediment study under unaided eyes and binocular microscope as well as using sieving techniques.

Specific Objectives:
Study of rocks in hand specimens and thin-sections to describe their textures, structures, mineralogy and origin. Study of sediments under unaided eyes, binocular microscope and sieves methods

COURSE CONTENTS
Lab 1: Study of optical properties of igneous rock forming minerals.

Lab 2: Calculation of Normative Minerals (NORM) from given chemical composition of rocks (silica saturated).

Lab 3: Calculation of Normative Minerals (NORM) from given chemical composition of rocks (silica undersaturated).

Lab 4: Study of igneous rocks in hand specimens with emphasis on rock forming minerals, texture, structure, genesis and classification (acidic and intermediate rocks).

Lab 5: Study of igneous rocks in hand specimens with emphasis on rock forming minerals, texture, structure, genesis and classification. (basic and ultrabasic rocks).

Lab 6: Learning techniques of thin sectionspreparation.

Lab 7: Study of igneous rocks in thin sections with emphasis on rock forming minerals, texture, structure, genesis and classification (acidic and intermediate rocks).

Lab 8: Study of igneous rocks in thin sections with emphasis on rock forming minerals, texture, structure, genesis and classification (basic and ultrabasic rocks).

Lab 9: Study of optical properties of metamorphic index minerals.

Lab 10: Study of metamorphic rocks in hand specimens with emphasis on mineral assemblages, texture, structure, genesis and metamorphic history.

Lab 11: Study of metamorphic rocks in thin sections with emphasis on mineral assemblages, texture, structure, genesis and metamorphic history.

Lab 12: Study of metamorphic rocks in thin sections with emphasis on poly-deformed and poly-metamorphosed rocks.

Lab 13: Study of microstructures and shear sense indicators in thin sections of oriented rocks.

Lab 14: Preparation of composition-paragenesis diagrams (chemographic diagrams).

Lab 15: Determination of age of minerals/rocks from isotope analysis.

Text and Reference Books:

1. Principles of Igneous and Metamorphic Petrology (second edition). John D. Winter, PHI Learning Private Limited, New Delhi-110001, 2012, p. 702 (original U.S. edition).
2. Igneous and Metamorphic Petrology. Myron G. Best, CBS Publisher and Distributors, 485, Jain Bhawn Bhola Nath Nagar, Shahdra, Delhi-110032, p. 630 (original U.S. edition).

3. The study of rocks in thin sections. W.W. Moorhouse.CBS Publishers and Distributors. Shahdara, Delhi-110 032 (first Indian print in 1985), p. 514. (Original print in U.S.).
4. Petrography of Igneous and Metamorphic Rocks. Anthony R. Philpotts, Prentice Halls, Inc. New Jersey-0-13-6623-13-1, p. 178 (original U.S. edition).
5. Petrography: An introduction to the study of rocks in thin sections. Howel Williams, Francis J. Turner and Charles M. Gilbertj. CBS Publishers and Distributors. Shahdara, Delhi-32, p. 626 (first Indian print in 1985), p. 514. (Original print in New York).
6. Study of minerals and rocks in thin sections. Lalu P. Paudel; Publisher: Geo-Science Innovations (P) Ltd., Kirtipur, Kathmandu, Nepal, p. 102 (Original print in Nepal, 2011).

SEMESTER I

Course Title: Practical II: Sedimentology and Sedimentary Petrology Full Marks: 25
Course No.: EGE528 Pass Marks: 12.5
Nature of the course: Practical Credit: 1 (45 hrs)

COURSE DESCRIPTION
Students will analyse and study unconsolidated sediments for composition and textures, and study sedimentary rocks in hand specimen and thin-section.

OBJECTIVES
General Objectives. To provide students with the knowledge and skills of description, classification, nomenclature and interpretation of sediments, and rock samples both in handspecimens and under polarizing microscope.

Specific Objectives:
- Study of rocks in hand specimens and thin-sections to describe their textures, structures, mineralogy and origin.
- Study of sediments under unaided eyes, stereoscopic microscope and by grain size analysis methods

COURSE CONTENTS
Sedimentology and Sedimentary Petrology Practicals
Lab 1: Grain size analysis of unconsolidated gravelly and sandy sediments using sieve methods.
Lab 2: Grain size analysis of unconsolidated silts and clay sediments using pipette method.
Lab 3: Analysis of sphericity, roundness and surface features of unconsolidated sands under stereoscope
Lab 4: Analysis of particle composition, form, sphericity, roundness and surface features of unconsolidated gravelly sediments
Lab 5: Construction of velocity distribution in stream channel and discharge calculation using Area-Velocity Method.
Lab 6: Plotting of sediment rating curve using published data on discharge and suspended sediment concentration of Himalayan rivers from Department of Hydrology and Meteorology, Government of Nepal.
Lab 7: Plotting, treating and Interpretation of paleoflow data using stereonet.
Lab 8 and 9: Introduction to the polarizing microscope setups. Study of siliciclastic rocks in hand specimens and under polarizing microscope for texture
Lab 10 and 11: Study of siliciclastic rocks in hand specimens and under polarizing microscope for composition
Lab 12 and 13: Study of carbonate rocks in hand specimens and under polarizing microscope for texture
Lab 14 and 15: Study of carbonate rocks in hand specimens and under polarizing microscope for composition

Text and reference books

1. Boggs Jr. S. (2009): Petrology of Sedimentary Rocks. Second Edition. Cambridge University Press. 600p.
2. Tamrakar N. K. (2011): Practical Sedimentology, Bhrikuti Academic Publication, Kathmandu, 232p.
3. Collinson, J. D. and Thompson, D. B. (1994): Sedimentary Structures, CBS Delhi, 207 p.
4. Adam, A.E., Mackenzie, W.S. and Guilford, C. (1988). Atlas of Sedimentary Rocks under the Microscope. ELSB, Longman Group, UK. 104p
5. Tamrakar, N.K. (2013). Handbook of field geology with reference to the Siwaliks. Central Department of Geology, Tribhuvan University, Kirtipur, Kathmandu, Nepal. 162p.
6. Lindholm R. C. (1991): A Practical Approach to Sedimentology, CBS Publishers and Distributors Delhi, 276 p.
7. Folk, R.L. (1980): Petrology of Sedimentary Rock. Hemphil Publishing Company, Austin Texas, 184p.
8. Freidman G. M. and Sanders J. E. (1978): Introduction to Sedimentology, Wiley, New York.
9. Pettijohn F. J. (1984): Sedimentary Rocks. 3rd edition, CBS Delhi, 628 p.

SEMESTER: I

Course Title: Practical III Structural Geology and Geology of Himalaya
Course No.: EGE529 Full Marks: 25
Nature of the course: Practical Credit 1 (45 hrs) Pass Marks: 12.5

Course Contents
(Structural geology: 0.5 Cr., 22.5 hrs)
Lab 1: Contours and topography. Reltionship between contours and contacts. Description of geomorphological and man-made features from topographic maps, construction of profiles.
Lab 2: Understanding the rule of V's, recognization of inliers, outliers, windows, klippe.
Lab 3: Study of structural features and stratigraphic sequence of the given geological maps.
Lab 4: Study of geological maps and preparation of geological cross-sections of horizontal, inclined, vertical and folded beds.
Lab 5: Study of geological maps with unconformity, faults and dykes.
Lab 6: Determination of apparent and true thickness of beds.
Lab 7: Determination of through of faults.
Lab 8: Stereographic projection techniques
Lab 9: Three point problems
Lab 10: Geometrical and stereographic techniques for the determination of net slip, dip slip and strike slip along the fault planes
Lab 11: Busk construction of parallel folds

Textbooks
1. Hobbs, B. E., Means, W. D., and Williams, P. F. (1976): An Outline of Structural Geology, John Wiley and Sons, 571 p.
2. Ramsay, J. G. (1967): Folding and Fracturing of Rocks, McGraw Hill Inc., 568 p.
3. Passchier, C. W. and Trouw R. A. J. (2003): Micro-tectonics, Springer, 253 p.
4. Ramsay, J. G. and Huber, M. I (1983): The Techniques of Modern Structural Geology, Volume 1: Strain Analysis, Academic Press, 307 p.

Reference Books
5. Bayly, B. (1991): Mechanics in Structural Geology, Springer-Verlag, 253p.
6. Johnson A.M. (1977): Styles of Folding, Elsevier Scientific Publishing Company, 406 p.
7. McClay, K. R. (1987): The Mapping of Geological Structures, John Wiley & Sons Inc., 161 p.
8. Ragan D. M. (1985): Structural Geology, An Introduction to Geometrical Techniques,3rd edition,John Wiley & Sons Inc., 393 p.
9. Means W. D. (1985): Stress and Strain Basic concepts of continuum mechanics for geologists, Springer-VerlagNew York, 339 p.
10. Davis G. H. and Reynolds S. J. (1996): Structural Geology of rocks and regions, John Wiley & Sons Inc., 776 p.

(Geology of the Himalaya : 0.5 Cr., 22.5 hrs)
Course Contents:
Lab 1: Evolution of the Himalaya. Briefly describe the following features:
Block diagram comprised of Achaean to Eocene strata according to Yin (2006)
Late Paleocene (60 – 54 Ma) depositional and subduction history during India-Asia collision
Eocene (54 – 34 Ma) depositional and subduction history during India-Asia collision
Oligocene (34 – 21 Ma) depositional and subduction history during India-Asia collision
Early and Middle Miocene (20 – 12 Ma) depositional and subduction history during India-Asia collision
Late Miocene and Pliocene (12 – 5 Ma) depositional and subduction history during India-Asia collision
Lab 2: Preparation of tectonic map of the Himalaya and its adjacent areas.

Briefly describe the major geomorphological, geological and tectonic features of the area such as:

The major syntaxes in the Himalaya
Extension of Karakorum Fault
Orogenic sediments and ophiolites, Tethys Himalaya, Higher Himalaya, Lower Himalaya, Sub-Himalaya, Krol Belt and Indian Shield
Indus-TsangPo Suture, Main Mantle Thrust, MCT, MBT and HFT

Lab 3: Preparation of the Geological map and schematic cross section of Nepal and describe major geological features such as:

The major tectonic sub-division of Nepal
The major geology of each tectonic zones focusing on lithology i.e. sedimentary, metamorphic and igneous bodies with their distribution in space
The major thrusts, nappes, klippes and windows

Lab 4: Study of the Lithostratigraphy and magnetostratigraphy of the Siwaliks: Prepare lithostratigraphic columns of major sections of the Siwaliks incorporating with magnetostratigraphy from Nepal and make a correlation chart.

Lab 5: Study of the Lithostratigraphy of the Lesser Himalaya: Prepare lithostratigraphy of major sections of the Lesser Himalaya from Nepal and correlate them.

Lab 6: Study of the lithostratigraphy of Kathmandu Nappe and Dadeldhura Nappe. Prepare lithostratigraphy of Kathmandu Nappe and Dadeldhura Nappe.

Lab 7: Study of the Lithostratigraphy of the Higher Himalaya: Prepare lithostratigraphy of major sections of the Higher Himalaya from Nepal and correlate them.

Lab 8: Study of the Lithostratigraphy of the Tethys Himalaya: Prepare lithostratigraphy of major sections of the Tethys Himalaya from Nepal and correlate them.

Lab 9: Study of lithostratigraphy of the Kathmandu valley fill-sediments, Thakkhola graben fill-sediments and Pokhara valley fill-sediments.

Lab 10: Preparation of magmatic rocks distribution map of Nepal. Describe major features of the magmatic rocks (granite, nepheline syenite and trachyte) such as:

Field relation, texture, mineralogy, chemistry, and ages

Lab 11: Preparation of the seismotectonic map of Nepal and its cross-section. Describe the seismotectonic features such as:

Frequency and distribution of epicentral points with relation to major tectonic structures of the Nepal Himalaya, MHT, Co-seismic zone, Aseismic zone, Ramp

Text and Reference Books and research articles:

1. Dhital, M. R. (2015). Geology of the Nepal Himalaya: Regional Perspective of the Classic Collided Orogen. Springer, 498p.
2. Gansser, A. (1964). Geology of Himalaya. John Wiley and Sons Inc.
3. Valdiya, K. S. (1998). Dynamic Himalaya. University Press, New Delhi.
4. Mascle, G., Pecher, A., Guillot, S., Rai, S. M., Gajurel, A., 2013. Himalaya-Tibet collision. Nepal Geological Society.
5. Research articles in various issues of the journal of Nepal Geological Society (NGS), Stratigraphic Association of Nepal (SAN), Bulletin of the Department of Geology, TU, and other International earth science journals.
6. Geological Maps published by Department of Mines and Geology and Central Department of Geology.
7. An Yin, 2006. Cenozoic tectonic evolution of the Himalayan orogen as constrained by along-strike variation of structural geometry, exhumation history, and foreland sedimentation. Earth-Science Reviews, 76, pp. 1 –131.

SEMESTER: I

Course Title: Practical IV- Engineering Geomorphology Full Marks: 25
Course No.: EGE530 Pass Marks: 12.5
Nature of the course: Practical Credit 1 (45 hours)

COURSE CONTENTS

Lab 1: Geomorphic mapping (delineate different landforms) using topo-sheet
Lab 2: Geomorphic mapping (delineate different landforms) using satellite image
Lab 3: Mapping landslide morphology
Lab 4: Calculations of different morphometric parameters of the given river system
Lab 5: Engineering soil mapping based on DEM and satellite image
Lab 6: Engineering geomorphology for groundwater investigation
Lab 7: Engineering geomorphology for Geohazard assessment: Geomorphology based landslide hazard assessment
Lab 8: Engineering geomorphology for Geohazard assessment: Geomorphology based flood hazard assessment
Lab 9: Engineering geomorphology for Geohazard assessment: Geomorphology based Earthquake hazard assessment
Lab 10: Assessment of geomorphic expression of tectonic feature

Textbooks

7. Fookes PG., Lee EM, Griffiths JS. (2007). Engineering Geomorphology Theory and Practice. Whittles Publishing, CRC Press. 269p.
8. Fookes PG, Lee EM, Milligan G (2005). Geomorphology for Engineers. Whittles Publishing, CRC Press. 851p.

Reference books

7. Huggett RJ (2007). Fundamentals of geomorphology, Second Edition. ISBN 0-203-94711-8
8. Burbank DW and Anderson RS (2007). Tectonic Geomorphology, Blackwell Science.
9. McClay KR (1987). The Mapping of Geological Structures, John Wiley and Sons Inc., 161 p.
10. Chorley R, Schumm SA and Sugden DE (1984). Geomorphology, Methuen, 605p.
11. Thornbury DW (2000). Principles of Geomorphology, New age International (P) Limited, Publishers, India. 594 p
12. Burbank DW and Anderson RS.. Tectonic Geomorphology. Blackwell Science. Anbazhagan S, Subramanian SK and Yang X (2011). Geoinformatics in Applied Geomorphology. CRC Press- Taylor & Francis Group. ISBN 13: 978-1-4398-3049-9 (eBook)

SEMESTER: I

Course Title: Practical V- Remote Sensing and GIS Full Marks: 25
Course No.: EGE531 Pass Marks: 12.5
Nature of the course: Practical Credit 1 (45 hours)

COURSE CONTENTS

Lab 1: Determination of scale of aerial photo with the help of topographic map; stereo-viewing in stereoscope
Lab 2: Practicing elements of photo interpretation
Lab 3: Interpretation of aerial photo and satellite image: Extraction of geological information (lithology, structure/lineament etc.) from the aerial photographs and satellite image; preparation of geomorphic map.
Lab 4: Visualization and understanding the level of information that can be extracted from various earth resource satellites operating in the optical spectrum.
Lab 5: Image rectification and enhancement; Digital image classification - supervised and unsupervised
Lab 6: Introduction to the general interface available in GIS software; Georeferencing scanned map
Lab 7: Digitizing and editing
Lab 8: Spatial analysis, vector based analysis
Lab 9: Spatial analysis, raster based analysis
Lab 10: GPS data acquisition, import in GIS and prepare map

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.
4. Albert, CTL and Yeung, KW (2002). Concepts and Techniques of Geographical Information Systems, Prentice Hall.

Reference books

1. Lillesand T. M. and Kiefer R. W. (1994). Remote Sensing and Image Interpretation, John Wiley and Sons, mc, New York.
2. Peter A. Burrough and Rachael A. McDonnell (2004). Principles of Geographical Information Systems, Oxford University Press, 333p.

SEMESTER: I

Course Title: Field work Full Marks: 50
Course No.: EGE532 Pass Marks: 25
Nature of the course: Field Credit: 2 (15 days in field)

COURSE DESCRIPTION

The students will learn to read topographic maps and locate oneself on the map, identify and map rocks and minerals, identify and interpret structures in the field, prepare geological map and crossections, learn various surveying techniques and learn about geology and tectonics of the Nepal Himalaya.

OBJECTIVES

General Objectives. The main objective of this course is to give the knowledge, techniques and skill of geological mapping and surveying.

Specific Objectives. Identifying rocks and minerals in the field, their recording in field note books, measurement of dip, strike and other structural features, identifying various structures and their interpretations, preparation of geological maps and crossections. Surveying and route mapping.

COURSE CONTENT

The students will spend a total of 15 days in the field studying under supervision of the faculties. Students will learn to identify the rocks and minerals in the field, mapping and describing structures, and learn techniques and skills of observation, data recording, sampling, description, analysis and interpretation, learn about route mapping and preparation of geological maps, cross-sections and stratigraphic columns.

They will also learn to study weathering and erosion processes, and field characteristics of soil and study soil profiles. Students will also learn the basic surveying techniques. At the end of the field work the students should be able to describe rock outcrops, map rock outcrops, Interpret rocks, textures and structures and describe and interpret folds faults, joints and other geological structures and prepare a geologic map. Also, learn the different tectonic units of the Nepal Himalaya. Students are required to prepare a geological map in the scale of 1:25000 and route map in 1:5000 scales, and also prepare a detailed columnar section.

The fieldwork will be carried out in Nepal Himalaya region and visit various districts of Nepal. This will give the students the opportunity to observe rock types, structures and tectonics of the Himalaya.

Detail course for the field works:

Days in the field	Description	Credit 2 (112 filed work lecture hours)
Day 1	Departure to the fieldwork area; orientation and preparation for desk works	7 hours
Day 2	Geological Traverse	7 hours
Day 3	Geological Traverse	7 hours
Day 4	Geological Traverse	7 hours
Day 5	Geological Traverse	7 hours
Day 6	Route Mapping (1:5000 scale)	7 hours
Day 7	Route Mapping (1:5000 scale)	7 hours
Day 8	Columnar sectioning and establishment of a stratigraphic column	8 hours

Day 9	Columnar sectioning and establishment of a stratigraphic column	8 hours
Day 10	Geological Mapping of a given area (1:25000 scale)	8 hours
Day 11	Geological Mapping of a given area (1:25000 scale)	8 hours
Day 12	Geological Mapping of a given area (1:25000 scale)	8 hours
Day 13	Geological Mapping of a given area (1:25000 scale)	8 hours
Day 14	Geological Field Report writing	8 hours
Day 15	Field Viva and Return back from the fieldwork area	7 hours
		=112 hours

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Evaluation:

S.N.	Evaluation schemes	Marks in %	Marks in %
1	Fieldwork Task Performance	20%	80%
2	Field Attendance	20%	
3	Field Discipline	20%	
4	Field Report and Viva	20%	
5	Final Viva Voce and Fieldwork Presentation	20%	20%

Textbooks

1. Thrope R. S. and Brown G. C. (1995). The field description of igneous rocks, John Wiley and Sons, 154p.
2. Barnes, J. W. (1981). Basic Geological Mapping. Geological Society of London Handbook Series. No. 1, Open University Press.
3. Bowden, J. (2008). Writing a Report: how to Prepare, Write and Present Really Effective Reports. ISBN-10:1845282930, 223p.
4. McClay, K. R. (1987). The Mapping of Geological Structures. Open University Press, Milton Keynes, 161p.
5. Bennison, G. M. (1987). An Introduction to Geological Structures and Maps. Edward Arnold, London, 65p.
6. Tucker M. (1982). The field description of sedimentation rocks. Geological Society of London Handbook Series, No. 1, Open University Press.
7. Fry, N. (1984). The field description of metamorphic rocks. Geological Society of London Handbook Series, No. 3, Open University Press.

Reference books

1. Lisle, R. J. (1995). Geological Structures and Maps: A Practical Guide, 2nd Edition, Butterworth-Heinemann,Oxford, 104p.
2. Maltman, A. (1998). Geological maps: an introduction, 2nd Edition, John Wiley.
3. Gansser, A. (1964). Geology of the Himalayas, John Wiley and Sons Inc.
4. Journal of Nepal Geological Society (Various Issues)
5. Bulletin of Department of Geology (Various Issues)

SEMESTER II

SEMESTER: II

Course Title: Soil Mechanics and Foundation Engineering Full Marks: 75
Course No.: EGE561 Pass Marks: 37.5
Nature of the Course: Theory Credit 3 (45 hrs)

COURSE DESCRIPTION This course covers the introductory part of soil mechanics and foundation engineering.

OBJECTIVES

General Objectives: To provide introductory knowledge of soil mechanics and its application to understand engineering behaviour of soils, and deal with various types of foundation.

Specific Objectives: To provide fundamental knowledge and practical skills of:

- Structures, and strength of soils,
- Stress analyses in soils,
- Assessing foundation problems.

COURSE CONTENT

Soil Mechanics

Soil, plasticity and classification: Introduction, Soil size limits, Clay minerals, Nature of water in clay, Consistency of cohesive soils, Liquidity index, Activity, Grain-size distribution of soil, Weight–volume relationships, Relative density and relative compaction, Effect of roundness and nonplastic fines, Unified soil classification system.-**4 hours**

Effective stress, pore water pressure and drainage: Principle of effective stress, Nature of effective stress, Computation of effective stress under ground water table fluctuation, capillary action, surcharge and seepage, Pore pressure due to drained loading, undrained loading and consolidation, Volume change and drainage. -**4 hours**

Permeability and seepage: Introduction, Darcy's law, Validity of Darcy's law, Determination of coefficient of permeability in the laboratory, Variation of coefficient of permeability for granular soils, Variation of coefficient of permeability for cohesive soils, Directional variation of permeability in anisotropic medium, Effective coefficient of permeability for stratified soils, Determination of coefficient of permeability in the field, Factors affecting the coefficient of permeability, Seepage equation of continuity, flow nets, Hydraulic uplift force under a structure, Flow nets in anisotropic material, Seepage force per unit volume of soil mass, Safety of hydraulic structures against piping, Analysis of rainfall and infiltration in soil, Seepage analysis in slope and stability evaluation of slope materials. -**8 hours**

Consolidation and compaction: Introduction, Theory of one-dimensional consolidation, degree of consolidation under time dependent loading, Standard one-dimensional consolidation test and interpretation, Secondary consolidation, Calculation of one-dimensional consolidation settlement, Coefficient of consolidation, Compaction and its use for civil engineering project, Factors affecting compaction, Effect of compact efforts, Importance of compaction in pavement design, comparison of consolidation and compaction. Laboratory test for compaction, Determination of field unit of compaction, compaction of organic soil. **-6 hours**

Shear strength of soils: Introduction, Two-dimensional states of stress, Mohr's circles of total and effective stresses, Mohr–Coulomb failure criteria, Shearing strength of granular soils, Critical void ratio, Curvature of the failure envelope, Shear strength of granular soils, Shear strength of cohesive soils, Unconfined compression test, Vane shear test, Creep in soils, Ring shear test, direct shear test.- **6 hours**

Foundation Engineering

Bearing capacity and settlement of shallow foundations: Introduction, Basic definitions, Gross and net footing Pressure, Rankine's analysis, Prandtl's analysis, Terzaghi's bearing capacity theory, Types of shear failures, Ultimate bearing capacity in case of local shear failure, Effect of water table on bearing capacity, Bearing capacity of square and circular footings, Meyerhof's bearing capacity theory, Hansen's bearing capacity theory, Vesic's bearing capacity theory, IS code method, Skempton's analysis for cohesive soils, IS code method for cohesive soil, Bearing capacity from standard penetration test, Eccentrically loaded foundations, Settlement of foundations, Loads for settlement analysis, Immediate settlement of cohesive soils, Immediate settlement of cohesionless soils, Accuracy of foundation settlement prediction, Allowable settlement, Allowable soil pressure for cohesionless soils, Allowable soil pressure for cohesive soils, Plate load test. **-8 hours**

Piled foundations: Introduction, Types of pile, Vertical load bearing capacity of single vertical pile, Piles in cohesive soils, Piles in granular soils, Group action of piles, Negative skin friction, Lateral loads on piles, Pile testing.- **3 hours**

Introduction to Combined footings and mat foundation, Foundation on collapsible and expansive soils..**-2 hours**

Retaining structure and their foundation failure. Foundations in lake and river beds. Earth pressure theory.- **2 hours**

Introduction to foundations of towers and multi storey buildings. Bearing capacity of bed rock and soil deposits on slopes. **-2hours**

Textbooks

1. Braja M. Das (2009) Advanced Soil Mechanics, Third edition, Taylor and Francis: New York, London. 592 p.
2. Braja M. Das (2008), Principle of Geotechnical Engineering, Thomson Publications, 593p.
3. Lambe T. W. and Whiteman R. V. (2000). Soil Mechanics, SI Version, John Wiley & Sons.
4. Reddy, R. N. (2010). (ed.): Soil Engineering Testing, Design and Remediation. Gene-Tek Books, New Delhi.
5. Arora. K.R. (2011). Soil Mechanics and Foundation Engineering. Standard Publishers Distributors. Delhi, India. 886p.
6. Murthy, V.N.S. Advance foundation engineering, CBS publishers and distributors, India.

Reference books

1. Arora. K.R. (2011). Soil Mechanics and Foundation Engineering. Standard Publishers Distributors. Delhi, India. 886p.
2. Lambe T. W. and Whiteman R. V. (1969). Soil Mechanics, John Wiley & Sons 553 p.

SEMESTER: II

Course Title: Rock Mechanics Full Marks: 50
Course No.: EGE562 Pass Marks: 25
Nature of the Course: Theory Credit 2 (30 hours)

COURSE DESCRIPTION
This course covers the introductory part of rock mechanics including rock engineering applications.

OBJECTIVES
General Objectives. To provide introductory knowledge of rock mechanics and its application.

Specific Objectives. To provide fundamental knowledge of:

Rock types and their relation with the index and engineering properties of rocks, Rock discontinuities and their role in rock engineering practices,

Application of rock mechanics in slope stability, foundation and tunnelling.

Introduction and index properties of rocks: Rock as a geological material; What is rock mechanics?; Recent developments in rock mechanics; Fields of application of rock mechanics; Nature of rocks; Sources of information in rock mechanics; Index properties – density, unit weight, porosity, permeability, sonic velocity, slack durability, swelling, drillability and blastability. -**2 hours**

Engineering classification of rock and rock mass: Definition and properties of rock mass; Rock mass classification – RQD, RSR, RMR, Q-system, GSI, RMi, N, MRMR and other rock mass classification schemes; limitations of rock mass classifications, modifications. -**4 hours**

Stress, strain, deformation and failure criteria: Principal stresses; strain; stress and strain tensor; principal stresses in two dimension; principal stresses in three dimension; shear stresses; Mohr's circles of stress in two dimensions; principal strains in two dimensions; principal strains in three dimensions; volumetric strain; strength and elasticity of rock; stress-strain relationship; stress-strain models; anisotropy; non-linier elasticity; plasticity; failure modes; failure criteria – M-C, H-B and Druker-Parger. -**6 hours**

Laboratory testing of rock: Point load test; Compression test- Uniaxial compressive strength test, bi-axial compressive test, tri-axial test, poly-axial compressive test; tensile test- direct tensile strength test, Brazilian test, flexural test; Shear test. -**2 hours**

Rock mass discontinuity: Introduction; Types of discontinuities; Discontinuity measurement and mapping; Stereographic projection; Stereographic representation of discontinuity data; Discontinuity data analysis; Characteristics of discontinuities; Discontinuity survey techniques, Joint wall roughness coefficient (JRC); Joint wall compressive strength (JCS); Joint matching coefficient (JMC); Residual angle of friction; Shear strength of joints, software and computer applications. -**4 hours**

Rock deformation and In-situ tests: Introduction; definition of in-situ and induced stresses; in-situ stress measurement techniques; stress and deformation monitoring devices, deformation modulus and GSI, open-end test in field, packer test; flow through feature; field deformability test- plate load test, shear test, Goodman jack test, plate jacking test; correlations between various tests. -**5 hours**

Underground structures and Rock foundation: Introduction; rockmass evaluation for subsurface structures, stress development in underground excavations, Rock reinforcement and grouting, bearing

capacity; stress distribution in rocks; shallow and deep foundation; deformation of dam foundation, foundation treatment. **-4 hours**

Application of rock mechanics to rock slope engineering: Introduction, modes of failure of slopes in hard rock, kinematic analysis of slopes, analysis of wedge and plane sliding on stereographic projection, analysis of rock fall hazards, analysis of slides composed of two blocks, stabilization of rock slopes, rock anchors. **-3 hours**

Textbooks

1. Richard E. Goodman (1989) Introduction to Rock Mechanics , John Wiley & sons
2. An Introduction to Rock Mechanics, edited by H. Book, Department of Civil and System Engineering, James Cook University of North Queensland
3. E. T. Brown (1993). Rock Mechanics for Underground Mining by B.H.G Brady and, 2nd edition, Chapman & Hall, Engineering Rock Mechanics by John A. Hudson and John P. Harrison, Pergamon, 1997
4. Chapman & Hall (1993).Discontinuity Analysis for Rock Engineering by Stephen D. Priest,
5. Weijiermars R., Principles of rock mechanics. Lectures in Geoscience. Alboran Science Publishing. 359p.
6. Hoek, E. (2000). Rock Engineering: course note by E. Hoek. 313p.
7. Kolymbas, D., (2005). Tunnelling and Tunnel Mechanics A Rational Approach to Tunnelling. Springer-Verlag Berlin Heidelberg. 311p.

Reference books

1. Hoek, E. and Bray J. (1977). Rock Slope Engineering, Institute of Mining and Metallurgy, London, 358p
2. Peng, S. and Zhang, J. (2007). Engineering Geology for Underground Rocks. Springer-Verlag Berlin Heidelberg, 319p.

SEMESTER: II

Course Title: Applied Geophysics Full Marks: 50
Course No.: EGE563 Pass Marks: 25
Nature of the course: Theory Credit 2 (30 hours)

COURSE CONTENTS

Introduction

Geophysics and Geophysical prospecting, Geological applications of geophysical methods, Regional geophysics, oil and gas geophysics, ore geophysics, ground water geophysics and engineering geophysics.-**2 hours**

Geophysical data acquisition, processing and interpretation

Geophysical data: temporal and spatial data, Geophysical data and time series, Analog versus digital data, digital data recording and sampling theory, Geophysical data in time domain, Fourier transform and geophysical data in frequency domain, Data filtering, convolution and deconvolution, Correlation and autocorrelation, Qualitative and quantitative interpretation of geophysical data, Inversion and forward modelling.-**4 hours**

Gravity method

Gravitational potential, Gravity anomaly: regional and residual anomaly, Gravity data reduction, qualitative and quantitative interpretation-**3 hours**

Magnetic method

Magnetic susceptibility of rocks and their ranges, elements of earth magnetic field, Magnetometers: Fluxgate and Proton Precession Magnetometers. Qualitative and qualitative interpretations. Application of magnetic methods. **-2 hours**

Electrical methods

Electrical properties of geological materials, Electrical potential caused by a point source in the subsurface, Electrical potential caused by a point source on the ground surface, Electrical potential caused by two point sources on the ground surface, Quadripole and potential difference at two potential electrodes at the ground surface, Self potential: cause and application, Resistivity method: Electrode arrays, Electrical sounding and profiling, Mise-a-la mase method, Equipotential line method, Induced polarization: Measurement of IP in time domain and frequency domain, Data processing and interpretation**.** Magnetotelluric method: basic principals, magentotelluric for deep engineering exploration-**7 hours**

Seismic Method

Stress-strain relation and propagation of seismic waves through geological materials, Continuous change of seismic velocity with depth, Group and phase velocity, Coherence, Time-distance relations for horizontal and inclined layers, Seismic refraction: Data processing and interpretation, Seismic reflection: Data processing and interpretation, Microtremor and its application.-**8 hours**

Ground penetrating radar

Basic theory, Dielectric constants of geological materials, Reflection profiling, GPR as robust tool for very shallow engineering problems-**2 hours**

Well logging. Objectives of well logging, Borehole environment, surface logging setup, sources of SP in wellbore, Archie's law and Darcy's law.-**2 hours**

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. Lowry W. 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.

SEMESTER: II

Course Title: Hydrogeology Full Marks: 50
Course No.: EGE564 Pass Marks: 25
Nature of the course: Theory Credit 2 (30 hours)

COURSE DESCRIPTION
Groundwater Hydrology gives in-depth understanding of movement of water on Subsurface of the earth. It also provides the essentials for exploration, drilling, development, and management of groundwater.

OBJECTIVES
General Objective
To give in-depth knowledge and understanding of sub-surface and groundwater hydrology.

Specific Objectives are to provide the students with in-depth knowledge and practical skills on:
- Sub-surface flow and ground water balance
- Various applications of hydrogeology
- Groundwater exploration
- Well hydraulics, well design, well drilling, and development techniques, and
- Groundwater monitoring

COURSE CONTENTS
Introduction: Introduction to surface and Groundwater hydrology, Hydrologic cycle, its application and scope.

Soil moisture and groundwater: Vertical distribution of groundwater, Hydro-geological parameters of earth materials, groundwater aquifers, water table, equipotential lines. **-1 hour**

Groundwater movement: Darcy's law, groundwater flow equations, hydraulic conductivity, Groundwater flow rates and directions, flow lines, flow nets, general flow equations. steady and unsteady flow. Multiple well systems, specific capacity. **-2 hours**

Geology of groundwater occurrence: Unconsolidated aquifers (glaciated terrains, alluvial valleys, alluvium in tectonic valleys), Lithified sedimentary rocks (complex stratigraphy, folds and faults, clastic sedimentary rocks, carbonate rocks, coal and lignite, Igneous and Metamorphic rocks, Groundwater in permafrost regions, coastal plain aquifers, groundwater in Desert areas. **-2 hours**

Surface and subsurface investigations of groundwater: Geological methods, remote sensing, Geophysical exploration and logging, test drilling, water level measurements, hydrogeological mapping. -3 hours

Well hydraulics and pumping test analysis: Steady unidirectional flow, steady radial flow to the wells, well in uniform flow, unsteady radial flow in confined, unconfined, and leaky aquifers, well flow near aquifer boundaries, multiple well systems, well losses and specific capacity, Thiem equation, Theis equation, Cooper-Jacob equations, Hantush equations and their applications. **-2 hours**

Water Wells and Well Drilling: Types of wells, well construction methods, types of drilling, well completion, well development, pumping test and its applications. **-1 hour**

Water Well Pumps: Variable displacement pumps,positive displacement pumps, pumps used to circulate drilling fluids, airlift pumping, pump selection,Specification of pumps for deep and shallow tube wells,

pumps suction conditions and beyond suction conditions, Plant requirements and pumphouse design and safety precautions. water storage. well and pump maintenance and rehabilitation-.**2 hour**

Groundwater Quality: Water quality analysis, physical, chemical and biological quality, water quality representations, water quality sampling, water quality criteria. Water pollution; causes and types of pollution, evaluating pollution potential .Disinfection procedures required to maintain sanitary well during drilling, sealing the well heads, sealing abandoned wells. **-3 hour**

Groundwater Development and Management: Dynamic equilibrium in natural aquifers, groundwater budgets, management of potential aquifers, water law, conjunctive use of groundwater and surface water. **-1 hour**

Groundwater Resources of Nepal: Utilisation, quality, and management. Groundwater scenario in other countries.- **1 hour**

Water Tracing Techniques: Water tracing definition, water tracing results, kind of tracers, Artificial tracers, Man-made tracer, Demand on tracers, objective of tracing experiments, Selection of injection points, Selection of tracers, Quantity of the injected tracers, Preparation of tracing experiments, injection of tracers, Collection of samples and observation, Determination of tracers in field, Dyes for water tracer, Flurometer, use of salts for water tracing, Advantage and disadvantage of salt tracer.- **3 hours**

Ground water systems drinking and irrigation: Categorization of tubewell irrigation system in context of Nepal and India, Shallow tube well irrigation systems, Deep tube well drinking and irrigation systems, open channels and buried pipe distribution systems and its advantages. Supporting structures in tubewell drinking and irrigation systems. Users' participation and project promotion, Activities and participants in water supply planning, Target well capacity, command area and well site selection, planning and management of groundwater irrigation system. Estimating and costing of tube well irrigation system. **-3 hours**

Ground water in hard rock areas: Hard rock definition, investigation techniques, mapping methods, surface and borehole geophysics, Exploration for ground water and well sites, well construction, well hydraulic and yield analysis, Hydro fracturing, hydrogeological environment of fractured rocks, Ground water flow and resources in fractured rocks, chemical and physical properties of groundwater in fractured rocks, Anthropogenic impacts on fractured rocks, optimization of sustainable water management in fractured rocks, Ground water protection in hard rock areas, Springs and its fluctuation factor, well and spring inventory in the area. Groundwater resources in the hills and mountain regions of Nepal.--**6 hours**

Textbooks

1. Fetter, C. W., (1990). Applied Hydrogeology, 2nd ed., CBS Publisher India.
2. Todd, K. D. (1980). Groundwater Hydrology 2nd ed., John Wiley &Sons Inc., New York
3. Freeze R. Allan and Cherry John A.(1979).Groundwater, PRENTICE HALL, Englewood Cliffs,

Reference books

1. Driscoll, F. G. (1989). Groundwater and Wells, Johnson Filtration Systems lnc., Minnesota
2. Raghunath, H. M (1992). Groundwater (2nd ed), Wiley Eastern Limited, New Delhi, India.
3. Jones, G. P. and Rushton, KR. (1981). Pumping-test analysis, Groundwater Resources Evaluation (Lloyd)
4. Garg, S. P. (1982). Groundwater and Tubewells (2nd ed.), Oxford and IBH publishing Co. Ltd. New Delhi.

SEMESTER: II

Course Title: Site investigation and Exploration Full Marks: 50
Course No.: EGE565 Pass Marks: 25
Nature of the Course: Theory Credit: 2 (30 hours)

OBJECTIVES

- To know the principles of site investigation and subsurface exploration
- To know the sampling techniques and preserving samples using advanced sampling techniques.
- To understand the importance of field testing and geotechnical instrumentation in the field to get solutions for different soil conditions

Unit 1: Introduction-2 hours

Scope and objectives of site investigation, Surface and subsurface investigation, exploration objectives, trend of site investigation in infrastructure development projects in Nepal

Unit 2: Site Investigation and Subsurface Exploration Principles-4 hours

Preliminary desk studies, planning an exploration programme, spacing and depth of boring, stabilization of bore holes, soil profile, bore logs, data presentation, soil investigation and exploration reports.

Unit 3: Field Testing-6 hours

Importance of field testing, field testing methods: field vane shear test, penetrometer test, field permeability test, penetration testing, standard penetration test, static cone penetration test, dynamic cone penetration test, plate load test, data interpretation.

Unit 4: Exploration Techniques-6 hours

Methods of boring and drilling, non-displacement and displacement methods, drilling in difficult subsoil conditions, geophysical exploration and interpretation, seismic refraction and electrical resistivity methods, other geophysical methods.

Unit 5 : Samples and Samplers-6 hours

Type of samples, disturbed and undisturbed samples, sample disturbance, design features affecting sample disturbance, area and recovery ratio, RQD, types of samplers, methods for preventing loss of samples, shallow penetration samplers, advanced sampling techniques, preservation and handling of samples, Nepalese practice and standards, Laboratory Testing, the purpose of soil testing, available laboratory testing

Unit 6: Instrumentation-6 hours

Instrumentation in soil engineering, pore water pressure and groundwater level measurement, displacement measurement, strain gauges, resistance and induction type, load cells, earth pressure cells, settlement and heave gauges, piezometers and slope indications, inclinometer, references and standards.

Textbooks

1. Clayton, C R.I., Matthews, M.C. and Simons, N.E. (1982), Site Investigation, Second Edition, Department of Civil Engineering, University of Surrey, Oxford (England); Cambridge, Mass., USA : Blackwell Science, 466 p.
2. Hunt R.E. (1984), Geotechnical Engineering Investigation Manual, McGraw Hill.
3. Hanna T.H. (1985), Field Instrumentation in Geotechnical Engineering, Trans Tech.
4. Dunnicliff., J., and Green, G.E. (1993), Geotechnical Instrumentation for Monitoring Field Performance, John Wiley.
5. Nair, R.J. and Wood, P.M. (1987), Pressuremeter Testing Methods and Interpretation, Butter worths.
6. Lambe T. W. and Whiteman R. V. (2000). Soil Mechanics, SI Version, John Wiley & Sons.
7.

SEMESTER: II

Course Title: Advanced Mathematics and Geo-statistics Full Marks: 50
Course No.: EGE566 Pass Marks: 25
Nature of the Course: Theory Credit 2 (30 hrs)

COURSE DESCRIPTION

The students will learn the use of mathematics and statistical knowledge in engineering geological problems.

OBJECTIVES

General Objectives. The students will have the knowledge and skill and knowledge on practical mathematics and statistics.

Specific Objectives. The main objectives of this course is to provide the students the skills of mathematics and statistics, learn the mathematical and statistical analysis of geological data.

COURSE CONTENTS
MATHEMATICS

Mathematics as a tool for solving geological problems. Introduction, Mathematics as an approximation to reality, Using symbols to represent quantities, Subscripts and superscripts, Large numbers and small numbers, Manipulation of numbers in scientific notation, Use consistent units, Spreadsheets, Exercises: From Text Book (Mathematics. A Simple Tool for Geologists) 1.1, 1.2, 1.3,1.4,1.5,1.6,1.7,1.8,1.9,1.10,1.11,1.12. - **2 hours**

Common relationships between geological variables. Introduction, The straight line, Quadratic equations, Polynomial functions, Negative powers, Fractional powers, Allometric growth and exponential functions, Logarithms, Logarithms to other bases, Exercises: Form Text Book (Mathematics. A Simple Tool for Geologists) 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7,2.8, 2.9, 2.10, 2.11, 2.13, 2.14, 2.15. **-2 hours**

Equations and their manipulations. Introduction, Rearranging simple equations, Combining and simplifying equations, Manipulating expressions containing brackets, Rearranging of quadratic equations, Exercises: From Text Book (Mathematics. A Simple Tool for Geologists) 3.1, 3.2, 3.3, 3.4, 3.5, 3.6 ,3.7, 3.8, 3.9, 3.10, 3.11, 3.12. -**2 hours**

More advanced equation manipulation. Introduction, Expressions involving exponentials and logarithms, Simultaneous equations, Quality assurance, Exercises: From Text Book (Mathematics. A Simple Tool for Geologists) 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 4.10. - **2 hours**

Graphs and representation. Introduction, Log-normal and log-log graphs, Triangular diagrams, Polar graphs, Equal interval, equal angle and equal area, projections of a sphere, Exercises: From Text Book (Mathematics. A Simple Tool for Geologists) 6.1, 6.2, 6.3, 6.4, 6.5, **-2 hour**

Matrix Algebra. The Matrix, Elementary Matrix Operations, Matrix Multiplication, Inversion and Solution of Simultaneous Equations, Determinants, Eigenvalues and Eigenvectors, Eigenvalues, Eigenvectors, Exercises: From the Text Book (Statistics and Data Analysis in Geology, John *C.* Davis) 3.1, 3.2, 3.3, 3.4 and 3.5.- **1 hour**

Vectors in two and three dimensions. Two and three dimensional vectors, scalar products, vector products, lines and planes. **-1 hour**

Differential calculus. Introduction, Rates of geological processes, Graphical determination of rates of change, Algebraic determination of the derivative, Standard forms, The product rule, The quotient rule, The

chain rule, Why Calculus in geological science, Higher derivatives, Maxima and minima, Higher order derivatives, mean value theorems, taylor and maclaurin series, tangent and normal, curvature, asymptotes, curve tracing, exercises: From Text Book (Mathematics. A Simple Tool for Geologists) 8.1, 8.2, 8.3, 8.4, 8.5, 8.6, 8.7,8.8, 8.9, 8.10, 8.11, 8.12, 8.13, 8.15. -**1 hour**

Integral calculus. Introduction, Exercise for the area under the curve, Indefinite integration, Definite integration, Integration of more complex expressions, Applications of integration, Integrating discontinuous functions, Applications of Integral, Areas, lengths, volumes, surfaces, Exercises: From Text Book (Mathematics, A Simple Tool for Geologists) 9.1, 9.2, 9.3, 9.4, 9.5, 9.6, 9.7, 9.8.- **1 hours**

Differential Equation: Definitions and classification of differential equations, Solutions of differential equations, Some mathematical models, Separable equations, Homogeneous equations, Equations reducible to homogeneous equations, Modeling with first order equations, Autonomous equations and population dynamics, Exact equations and integrating factors, Exercises: From Text Reference Book (Elementary Differential Equations and Boundary Value Problems, W Boyce and R. DiPrima:) -**1 hour**

STATISTICS

Statistics in Geology, Measurement Systems

Elementary Statistics

Probability, Continuous Random Variables, Statistics and descriptive statistics, Joint Variation of Two Variables, Induced Correlations, Log ratio Transformation, Comparing Normal Populations, Central Limits Theorem , Testing the Mean P-Values, Significance, Confidence Limits, the t-Distribution, degrees of freedom, confidence intervals based on t, A test of the equality of two sample means, the t-test of correlation.The Logarithmic and Other Transformations, Nonparametric Methods, Mann-Whitney test, Kruskai-Wallis test, Nonparametric correlation, Kolmogorov-Smirnov tests, Exercises: Selected exercise from the Text Book (Statistics and Data Analysis in Geology, John *C.* Davis) 2.1, 2.2, 2.3, 2.8, 2.9, 2.11, 2.12, 2.15, 2.16. 2.17.-**3 hours**

Analysis of Sequences of Data

Geologic Measurements in Sequences, Interpolation Procedures, Series of Events, Runs Tests, Least-Squares Methods and Regression Analysis, Confidence belts around a regression, Calibration, Curvilinear regression, Reduced major axis and related regressions, Structural analysis and orthogonal regression, Regression through the origin , Logarithmic transformations in regression, Weighted regression, Autocorrelation, Cross-correlation, Cross-correlation and stratigraphic correlation, Semivariograms, Modeling the semivariogram, Alternatives to the semivariogram, Spectral Analysis, Exercises: Selected exercise from the Text Book (Statistics and Data Analysis in Geology, John *C.* Davis), 4.2, 4.3, 4.7, 4.8, 4.12, 4.17.-**4 hours**

Spatial Analysis

Geologic Maps, Systematic Patterns of Search, Distribution of Points, Uniform density, Random patterns, Clustered patterns, Nearest-neighbor analysis, Distribution of Lines, Analysis of Directional Data, Testing hypotheses about circular directional data, Test for randomness, Test for a specified trend, Test of goodness of fit, Testing the equality of two sets of directional vectors, Spherical Distributions, Matrix representation of vectors, Displaying spherical data, Testing hypotheses about spherical directional data, A test of randomness, Fractal Analysis, Ruler procedure, Grid-cell procedure, Spectral procedures, Higher dimensional fractals, Shape, Fourier measurements of shape, Spatial Analysis by ANOVA, Computer contouring, Contouring by triangulation, contouring by gridding, Problems in contour mapping, Extensions of contour mapping, Trend Surfaces, statistical tests of trends, Two trend-surface models, Pitfalls, Kriging, Simple kriging, Ordinary kriging, Universal kriging, calculating the drift, block kriging, Statistical model validation, ROC and area under the curve, Exercises: Selected exercise from the Text Book (Statistics and Data Analysis in Geology, John *C.* Davis) 5.1, 5.4, 5.7, 5.9, 5.12, 5.14, 5.15, 5.17, 5.`8, 5.19.-**4 hours**

Analysis of Multivariate Data

Multiple Regression, Discriminant Functions, Tests of significance, Multivariate Extensions of Elementary Statistics, Equality of two vector means, Equality of variance-covariance matrices, Cluster Analysis.

Introduction to Eigenvector Methods, Including Factor Analysis, Principal Component Analysis, Closure effects on principal components, R-Mode Factor Analysis, Factor rotation, Maximum likelihood factor analysis, Q-Mode Factor Analysis , A word about closure, Principal Coordinates Analysis, Correspondence Analysis ,Multidimensional Scaling, Simultaneous R- and Q-Mode Analysis, Multigroup Discriminant Functions, Canonical Correlation, Exercises: Selected exercise from the Text Book (Statistics and Data Analysis in Geology, John *C.* Davis) 6.1, 6.6, 6.11, 6.16, 6.17, 6.19-**4 hours**

Textbooks

1. Mathematics. A Simple Tool for Geologists, David Waltham, Second edition, Blackwell Science Ltd, London, 217p.
2. Statistics and Data Analysis in Geology, John C. Davis, Third Edition, John Wiley & Sons, New York, 620 p.
3. E.W. Swokowski. Calculus with Analytic Geometry, Second Alternate Edition, PWS-Kent Publishing Co., Boston.

Reference books

1. E. Kreyszig. Advance Engineering Mathematics, Fifth Edition, Wiley, New York
2. W. Boyce and R. DiPrima: Elementary Differential Equations and Boundary Value Problems, 9th Ed., Wiley, India

SEMESTER: II

Course Title: Practical I- Soil Mechanics and Foundation Engineering Full Marks: 25
Course No.: EGE567 Pass Marks: 12.5
Nature of the Course: Practical Credit: 1 (45 hours)

SOIL MECHANICS

Lab 1: Determination of water content of a sample by a) oven-drying method, and b) pycnometer method
Lab 2: Determination of specific gravity of solids by a) the density bottle method, and b) pycnometer method
Lab 3: Determination of dry density of the soil by a) core cutter method, and b) water-displacement method
3 hours
Lab 4: Determination of particle size distribution of a soil by sieving, particle size distribution of a soil by hydrometer method
Lab 5: Determination of liquid limit and plastic limit of a soil specimen, shrinkage limit of a specimen of the remoulded soil
Lab 6: Determination of permeability of soil by a) constant-head permeameter, and b) the variable head permeameter
Lab 7: Consolidation test of various soil specimens
Lab 8: Unconfined compressive strength of a cohesive soil
Lab 9: Strength, cohesion and friction using Mohr-Coulomb failure criteria, from direct shear test and triaxial testing of soils
Lab 10: Compaction characteristic of a soil specimen by Proctor's test
Lab 11: California Bearing Ratio (CBR) of a soil specimen.

Text books

1. Sivakugan N., Arulrajah A., Bo M.W. (2011), Laboratory testing of soils, rocks, and aggregates, J. Ross Publishing, USA, 624p.
2. Das B.M. (2015) Soil Mechanics Laboratory Manual, Oxford University Press, USA, 336p

Reference books

1. ASTM: "1985 Annual Book of ASTM Standards", Volume 04.08: Soil and Rock; Building Stones. Published by ASTM in 1986.
2. British Standard 812: part 3:1975; Methods for testing aggregates, part 3 methods for determination of mechanical properties. Published by British Standards Institution, 1975.

SEMESTER: II

Course Title: Practical II- Rock Mechanics Full Marks: 25
Course No.: EGE568 Pass Marks: 12.5
Nature of the Course: Practical Credit: 1 (45 hrs)

Lab 1: Determination of density and porosity of rock	3 hours
Lab 2: Determination of moisture content of rock.	3 hours
Lab 3: Determination of specific gravity of rock.	3 hours
Lab 4: Determination of Schmidt hammers rebound hardness of rock	3 hours
Lab 5: Determination of swelling and slake durability of specimen	6 hours
Lab 6: Determination of point load strength index of intact rock	3 hours
Lab 7: Determination of Brazilian tensile strength index of intact rock	3 hours
Lab 8: Determination of unconfined compression strength of rock	6 hours
Lab 9: Determination of Young's Modulus of rock	3 hours
Lab 10: Determination of shear strength and triaxial compression strength of rock	6 hours
Lab 11: Determination of modulus of elasticity and Poisson's ratio	6 hours

Textbooks

1. Richard E. Goodman (1989) Introduction to Rock Mechanics , John Wiley & sons
2. An Introduction to Rock Mechanics, edited by H. Book, Department of Civil and System Engineering, James Cook University of North Queensland
3. E. T. Brown (1993). Rock Mechanics for Underground Mining by B.H.G Brady and, 2nd edition, Chapman & Hall, Engineering Rock Mechanics by John A. Hudson and John P. Harrison, Pergamon, 1997
4. Chapman & Hall (1993).Discontinuity Analysis for Rock Engineering by Stephen D. Priest,
5. Weijiermars R., Principles of rock mechanics. Lectures in Geoscience. Alboran Science Publishing. 359p.
6. Hoek, E. (2000). Rock Engineering: course note by E. Hoek. 313p.
7. Kolymbas, D., (2005). Tunnelling and Tunnel Mechanics A Rational Approach to Tunnelling. Springer-Verlag Berlin Heidelberg. 311p.

Reference books

1. Hoek, E. and Bray J. (1977). Rock Slope Engineering, Institute of Mining and Metallurgy, London, 358p
2. Peng, S. and Zhang, J. (2007). Engineering Geology for Underground Rocks. Springer-Verlag Berlin Heidelberg, 319p.

SEMESTER: II

Course Title: Practical III: Applied Geophysics Full Marks: 25
Course No.: EGE569 Pass Marks: 12. 5
Nature of the Course: Practical Credit 1 (45 hrs)

COURSE CONTENTS

Gravity Methods in Engineering Geology

Lab 1 Techniques of gravity surveys
Lab 2 Field data acquisition and data processing techniques, interpretation of result. 9 hours

Magnetic Methods in Engineering Geology

Lab 3 Magnetic surveying procedures
Lab 4 Field data acquisition and data processing techniques, interpretation of result.9 hours

Electrical and Electromagnetic Methods in Engineering Geology

Lab 5 Electrical resistivity survey methods (profiling and sounding), data processing and interpretation of results.
Lab 6 SP survey method, data processing and interpretation of results.
Lab 7 IP survey method, data processing and interpretation of results.
Lab 8 Eelectromagnetic survey method, data processing and interpretation of results. 18 hours

Seismic Method in Engineering Geology

Lab 9 Seismic refraction survey methods, data processing and interpretation of result Lab 10 Seismic reflection survey methods, data processing and interpretation of result 9 hours

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. Lowry W. (2007), Fundamentals of Geophysics, 2nd edition, Cambridge Univeristy Press, 381p.

Reference books

1. 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.

SEMESTER: II

Course Title: Practical IV: Hydrogeology Full Marks: 25
Course No.: EGE570 Pass Marks: 12. 5
Nature of the Course: Practical Credit: 1 (45 hrs)

COURSE CONTENTS

1. Preparation of ground water contour and hydrogeological maps
2. Preparation of lithological log and interpretation of aquifer, non-aquifer and screen length
3. Interpretation of constant head boundary, water flow line, equipotential line and flow net
4. Problems of relating to well hydraulics/ analysis of pumping test data and calculation of aquifer properties by different methods.
5. Interpretation of hydraulic head, pressure head and elevation head and related calculations
6. Well design techniques with introducing housing, casing, strainer and its types
7. Calculation of required discharge and power of the pumps
8. Evaluation of groundwater potential in unconsolidated sedimentary and hard rock terrain
9. Assessment of groundwater recharge
10. Preparation of hydrogeomorphic maps using remote sensing imageries and different geophysical data for ground water resources assessment
11. Analysis and presentation of ground water quality parameters for drinking and irrigation

Textbooks

4. Fetter, C. W., (1990). Applied Hydrogeology, 2nd ed., CBS Publisher India.
5. Todd, K. D. (1980). Groundwater Hydrology 2nd ed., John Wiley &Sons Inc., New York
6. Freeze R. Allan and Cherry John A.(1979).Groundwater, PRENTICE HALL, Englewood Cliffs,

Reference books

5. Driscoll, F. G. (1989). Groundwater and Wells, Johnson Filtration Systems lnc., Minnesota
6. Raghunath, H. M (1992). Groundwater (2nd ed), Wiley Eastern Limited, New Delhi, India.
7. Jones, G. P. and Rushton, KR. (1981). Pumping-test analysis, Groundwater Resources Evaluation (Lloyd)
8. Garg, S. P. (1982). Groundwater and Tubewells (2nd ed.), Oxford and IBH publishing Co. Ltd. New Delhi.

SEMESTER: II

Course Title: Field Work (15 days) Full Marks: 50
Course No.: EGE571 Pass Marks: 25
Nature of the course: Field work Credit: 2 (15 days)

COURSE DESCRIPTION

This course requires previous geological field experience and provides the students with hands-on practice in outcrop mapping, geomorphic interpretation and simple field testing of rocks and soils for geotechnical purposes. A variety of rock masses, soils and topography in the various geomorphic provinces of Nepal will be mapped at range of scales. The students will develop their skills of observation and description and advance their skills of detailed and accurate logging and mapping.

OBJECTIVES

General Objectives. To give in-depth knowledge of outcrop mapping, geomorphic mapping and simple field testing of rocks and soils and preparation of engineering geological map.

Specific Objectives. To provide the students in-depth knowledge of:
Identify, describe and classify soil and rock mass, identify and describe topography from a geotechnical viewpoint, derive engineering geological information from topographic and geologic maps, construct engineering geological logs, maps and cross-sections, using engineering geological maps and keys to communicate a comprehensive synthesis of geotechnical conditions.

COURSE CONTENTS

Study of survey techniques required for engineering geological mapping. Outcrop mapping, structural analysis of rocks, Observation of different soil types, their field classification and description, Observation of intact rock, discontinuities, study of geomorphic features and interpretations, simple field testing of rocks and soils for geotechnical purposes and preparation of engineering geological map and cross-sections, and hazard map. Field work will be conducted in various districts of Nepal as per the availability of ongoing engineering projects and construction activities. Application of various rock mass classification systems in relation to civil engineering structures. Geophysical exploration techniques for various engineering geological projects. Report preparation and formal presentation for evaluation.

Textbooks

1. Hoek, E. (2000). Rock Engineering: course note by E. Hoek. 313p.
2. Kolymbas, D., (2005). Tunnelling and Tunnel Mechanics A Rational Approach to Tunnelling. Springer- Verlag Berlin Heidelberg. 311p.
3. Reddy, R. N. (2010). (ed.): Soil Engineering Testing, Design and Remediation. Gene-Tek Books New Delhi.
4. Arora. K.R. (2011). Soil Mechanics and Foundation Engineering. Standard Publishers Distributors. Delhi, India. 886p.
5. Dobrin, M. B. and Savit, C. H. (1988). Introduction to geophysical Prospecting, McGraw-Hill Book Company, 867 p.
6. C. F. (1969). Elementary Seismology, S. Eurasia Publishing House Pvt. Ltd., 768 p.
7. Keller, G. V. and Frischknecht, F. C. (1966). Electrical methods in geophysical prospecting. Pergamon Press, 517 p.

SEMESTER III

SEMESTER: III

Course Title: Slope Stability and Landslide Engineering Full Marks: 75
Course No.: EGE621 Pass Marks: 37.5
Nature of the Course: Theory Credit: 3 (45 hrs)

OBJECTIVES

- To know the principles of slope stability analysis and state of the art methods
- To know the slope stabilization methods
- To understand the concepts of landslides, preventive and mitigation options and monitoring
- To know the landslide hazard and susceptibility techniques for the prediction of landslides
- To understand the risk assessment techniques, its quantification, evaluation and its use in critical decision making

COURSE CONTENTS

Unit 1: Slope Stability Concepts for Natural and Engineered Slopes -5 hours

Introduction, Modes of Failure, Factor of Safety Concepts, Pore Water Pressures, Piezometric Surface, Negative Pore Pressures, Embankments and Fills, Cut Slopes, Landfills, Factors Contributing to Slope Failures, Basic Concepts Applied to Slope Stability, Typical Input Data for Slope Stability Analyses, Geologic Conditions, Site Topography, Slope Material Properties, Identification and Interpretation of Groundwater Conditions in Slope, Groundwater Effects on Slope Stability, Effect of Seismicity, Back Analysis for Slope Stability.

Unit 2: Slope Stability Analysis Methods-8 hours

Block Analysis, Infinite Slope Analysis, Planar Surface Analysis, Circular Surface Analysis: Friction Circle Method, Method of Slices: Ordinary Method of Slices (OMS), Simplified Janbu Method, Simplified Bishop Method, Generalized Limit Equilibrium (GLE) Method, Comparison of Limit Equilibrium Methods, Design Charts: Historical Background, Stability Charts, Seismic Analysis: Pseudostatic Method, Newmark's Displacement Method, Computed Permanent Displacements, Factors Affecting Slope Stability Analysis, Effect of Tension Cracks on Stability Analysis, Effects of Vegetation, Foundation Loads on Slopes, Finite Element Method (FEM) in slope stability analysis, Available computer programs, Case studies on slope stability analysis, Concepts of SEEP/W, SLOPE/W and SIGMA/W of GeoStudio Packages, Fundamentals of Three Dimensional (3D) Slope Stability Analysis, Rock Slope Stability.

Unit 3: Slope Stabilization Methods-8 hours

Introduction, Flattening of Slope, Complete Removal of Slide Zone, Facility Relocation, slope stabilization through bioengineering, surface and subsurface drainage, Excavation, Reinforcement: Soil Nailing, Stone Columns, Reticulated Micropiles, Geosynthetically Reinforced Slopes, Retaining Walls, Gravity and Cantilever Retaining Walls, Drilled Shaft Walls, Tieback Walls, Surface Slope Protection, Soil Hardening, Compacted Soil, Cement Fill, Electro osmosis, Grouting, Lime Injection, Preconsolidation, Removal of Unstable Rock, kinematic analysis, Rock slope stabilization programs, Stabilization by rock reinforcement, Stabilization by rock removal, Rock bolting and anchoring, Resloping and unloading, Trimming, Rock nets, Protection measures against rock falls, Alternatives to Slope Stabilization, Cost Analysis of Stabilization Work.

Landslide Engineering

Unit 4: Landslide Concept, Classification, Causes and Triggers -5 hours

Landslide classifications and nomenclatures, parts of landslide, Causes and triggers of landslides, natural and anthropogenic factors in landslide occurrence, climate change and landslides, Rainfall-induced and Earthquake-induced landslides, factor of safety and stability margin of slopes, Field Investigations for landslides, landslide monitoring and need, use of Inclinometers and Piezometers, Laboratory shear strength measurements on soils for landslide study, Effects of clays and cohesive Soils for landsliding, Remote Sensing of Landslides.

Unit 5 : Remedial and Preventative Options of Landslides-5 hours

Prevention and mitigation of landslides, Remediation of Landslides, soil slope and rock slope features, landslide mitigation options, Dewatering systems, Seepage barriers, bioengineering technique of landslide stabilization, Retaining Walls, Earth Reinforcement systems, Slip Surface Strengthening, Erosion control Measures, success stories of landslide mitigations in Nepal

Unit 6: Estimating the Probability of Landslides -5 hours

Introduction, Discrete events, Multiple events, Continuous probability distributions and sampling, Subjective probability, Estimating probability from historical landslide frequency, Estimating probability from landslide-triggering events, Estimating probability through expert judgement, Estimating probability through the use of stability analysis.

Unit 7: Landslide Susceptibility and Hazard Analysis -4 hours

Concept of susceptibility, hazard, vulnerability and risk; landslide susceptibility and hazard assessment methods: Heuristic qualitative approach, statistical quantitative approach, and deterministic approach, use of GIS and remote sensing for hazard analysis, trend of landslide hazard assessment methods in Nepal.

Unit 8: Landslide Risk Assessment-5 hours

Vulnerability assessment, elements at risk mapping, Qualitative and qualitative risk, risk ranking matrix, risk curves, quantifying risk: Current annual risk, comparing the risks associated with different management options, Individual Risk, Societal Risk, Acceptable or tolerable risks, Economic risks, Loss of life, Environmental risk, Environmental acceptance criteria, Climate change uncertainty: implications for landslide management, risk assessment as decision making tool, trend of landslide risk assessment in Nepal.

Text books

1. Lee W. Abramson, Thomas S. Lee, Sunil Sharma and Glenn M. Boyce (2002). Stability and Stabilization Methods, John Wiley & Sons, Inc., 712 p.
2. Duncan C. Wyllie and Christopher W. Mah (2004), Rock Slope Engineering (Civil and mining), Spoon Press, 431 p.
3. A. K. Turner and R. L. Schuster (1996), Landslides: investigation and mitigation, National Academies Press, 673 p.
4. E. M. Lee and D. K. C. Jones (2004), Landslide risk assessment, Thomas Telford Limited, 454 p.

Reference books

1. J. Michael Duncan and Stephen G. Wright (2005), Soil Strength and Slope Stability, John Wiley & Sons, Inc., 280 p.
2. Y. M. Cheng and C. K. Lau (2008), Slope Stability Analysis and Stabilization (New methods and insight), Routledge, 241 p.
3. Denys Brunsden and David B. Prior (editor) (1984), Slope Instability, John Wiley & Sons, Inc., 620 p.
4. Landslide Risk Assessment (2005), Oldrich Hungr, Robin Fell, Rejean Couture, Erik Eberhardt (editors), Taylor and Francis, London, 771 p.
5. Landslide Hazard and Risk (2005), Thomas Glade, Malcolm Anderson, Michael J. Crozier (editors), John Wiley & Sons Ltd, England, 802 p.

SEMESTER: III

Course Title: Highway and Tunnel Engineering — Full Marks: 75
Course No.: EGE622 — Pass Marks: 37.5
Nature of the course: Theory Credit 3 (45 hours)

Content	*Hrs*
Introduction: Overview of tunnel and underground spaces; their requirement and sustainable development; classifications; major attention for their construction; advantage and disadvantages of tunnel and underground construction; Their planning; and their major uses and scopes. scope and challenges of tunnel development in Nepal	2
Tunnel components: General; parts of tunnel; tunnel section and its parts; shafts; adit; portal; tunnel shapes; tunnel construction affecting factors.	1
tunneling equipment: Introduction; classification of equipment (earth excavation, loading and casting units); equipment function, efficiency and other details; muck hauling equipment; haulage methods; tunnel jumbo; tunnel boring machine; selection of the equipment; and excavation equipment reliability related measures.	2
Tunnelling Methods: General methods of excavations - *D&B method:* general and mechanized, excavation cycle. *Road header method*: types, working principles and performance. TBM (Tunnel Boring Machine) method: hard rock TBM, types, working principles, operational features, technical characteristics, performance estimation; soft ground TBM, types, application ranges, calculations of soft ground conditions and performance. *Cut-and-cover method*: introduction, bottom-up construction, top-down construction, their advantage and disadvantage, selection of construction method. Other methods: immersed tube method; special methods.	2
Drilling and Blasting Techniques: Types of drilling, approaches and application; drilling accessories; rock drillability and index; types of drill bits and their design aspects; bit life and factors affecting the bit life; bit selection; drill plan design, Explosives; Properties of explosives; types of explosive; selecting suitable explosive; charging method, mechanics of blasting; blasting accessories; blasting design; pattern of holes, cuts, kerf and cut design, blasting pattern; damage zone control and over break, designing surface blasting.	4
Geological and Geotechnical Considerations for Tunneling: Geological structures; geological and engineering geological mapping; intact and rock mass properties; discontinuities characteristics of the area; rock weathering; Groundwater characteristics; gases in tunnel; rock mass class; testing of rock; Presentation of geotechnical data; Application of rock testing data; Face mapping; Tunnel logging.	2
Tunnel Investigation: Introduction; Stages of investigation; Reconnaissance and feasibility Studies; Detail investigation; Investigations for preconstruction planning, and Engineering; Geological and geotechnical investigation during construction; Drilling and logging; and Geophysical exploration.	4
Tunnel Construction and Environment: Selection of tunnel excavation method; Portal Construction; Tunnel advancement; Shaft Construction; Excavation sequence; Ventilation; Dust suppression; Lighting; Communication; Drainage and water control; Fire protection; Pollution and environment management.	4
Tunnel Supports: Terminology, Support and reinforcement principles, Types of supports; Rockbolts and Dowels - Introduction, Rockbolts, Mechanically anchored rockbolts, Resin anchored rockbolts, Dowels, Grouted dowels, Friction dowels or 'Split Set' stabilizers, 'Swellex' dowels, Cable bolts, and Load-deformation characteristics; Shotcrete Support. Introduction, Shotcrete technology, Dry mix shotcrete, Wet mix shotcrete, Steel fibre reinforced micro-silica shotcrete; Steel arches - Latice gutter and Still ribs; Pre cast frame; Ceiling cast; Wire mesh; Strap; Grouting; Final supports, Spiles and Forepoles.	4

Tunnel Support Design: Design of support; Empirical methods; Theoretical methods; Semi-theoretical methods; Design of steel ribs and lattice girders; Rock bolts; Support arch; Face supports; Precast Segment Lining, tunnel lining design.	2
Cavern and Shaft: Cavern, excavation methods, Sequential Excavation Method (SEM), New Austrian Tunneling Method (NATM), other methods, Cavern construction methods, stability analysis in cavern, support design in cavern; Shaft, shaft construction methods, ground stress on shaft, support in shaft.	3
Ground Behavior, Instrumentation and Monitoring: In-situ stress; Stress distribution and failure prediction; Underground openings: dimensions, shape, structural response, influence of geometry; Failures in underground excavation; Structurally control instability; Caving and subsidence; Purposes of Instrumentation and monitoring; Type of instruments and their function for tunneling and underground excavations; Planning and designing the monitoring; Recoding instrument data and analysis.	4
Excavation Design: *Massive elastic rock:* General principles of excavation design, Zone of influence of an excavation, Effect of planes of weakness on elastic stress distribution, Excavation shape and boundary stresses, Delineation of zones of rock failure, Support and reinforcement of massive rock. *Stratified rock:* Design factors, Rock mass response to mining, Roof bed deformation mechanics, Roof design procedure for plane strain, Roof beam analysis for large vertical deflection. *Blocky rock:* Design factors, Identification of potential block failure modes-Block Theory, Symmetric triangular roof prism, Roof stability analysis for a tetrahedral block, Design practice in blocky rock, Mathews stability chart method.	5
Tunneling Hazards and Construction Management: Introduction; Potential hazards; Mechanization and automation; Occupational hazards; Risk analysis. Tunnel construction planning and risk; Risk sharing and management; Tunneling rate; Work condition classification for tunneling rate; Management classification; Tunnel construction performance management.	2
Highway: Introduction, general terminology, classification, geological and geotechnical investigation of mountain road and valley road, economic appraisal and payback analysis, highway pavement materials and design, highway construction plan.	2
Half tunnel: Introduction, unsupported curve analysis, supported curve design, use of rock mass classification in half tunnels.	1
Highway tunnels: Highway tunnel components, alignment selection, risk analysis in road tunnels.	1

Text books:

1. Highway Engineering by Martin Rogers, Blackwell Publishing Ltd. 2003
2. Highway Engineering Handbook by Roger L. Brockenbrough. MC Graw Hill, 3rd edition

SEMESTER: III

Course Title: Construction Material Engineering Full Marks: 50
Course No.: EGE623 Pass Marks: 25
Nature of the Course: Theory Credit: 2 (30 hrs)

COURSE DESCRIPTION
The course of geological construction material engineering gives the knowledge and skills of geological and geotechnical inputs necessary for investigation, and selection of construction materials for various engineering structures.

OBJECTIVES
GENERAL OBJECTIVE:

- To give knowledge and understanding of geological construction materials for various civil engineering structures.
- To highlight the role of a geologist in finding and assessing construction materials.

SPECIFIC OBJECTIVE: To provide the students in-depth knowledge and practical skills of description, classification, testing, and field investigating for construction materials.

COURSE CONTENTS

Introduction to Geological Construction Materials: Definition and application of construction materials. Building stones. Large stones and ripraps. Natural and artificial aggregates. Cement. Gypsum, Clays for bricks and tiles-**3 hours**

Construction Aggregates: Definition. Categories of aggregates. Constituents of aggregates. Sampling methods and size. Aggregate shapes and gradation analyses. Specification and testing of construction materials: Physical tests. Mechanical tests. Chemical tests. Impurities tests. Stripping tests. Petrographic examination. Durability tests. Description and classification of aggregates-**3 hours**

Aggregates for concrete: Aggregates types in concrete. Key properties of aggregates used in concrete. Aggregate grading. Flakiness Index, Elongation Index, shape and surface textures. Water absorption, specific gravities, and unit weights of aggregates. Effect of grading on water absorption. Aggregate Impact Value. Aggregate Crushing Value. Los Angeles Abrasion. Point-load Strength Index. Unconfined Compressive Strength. Slake durability. Sulphate soundness. Alkali aggregate reactivity, Deleterious constituents. Specification for fine and coarse aggregates-**1.5 hours**

Pavement Construction Materials: Historical perspective. Pavement system Design and typical pavement types: Structural elements and functions. Pavement types. **Unbound Pavement Construction Materials:** Desirable properties of aggregates for unbound pavement. Resistance to wear. Influence of aggregate properties on degrading. Influence of moisture content on degradation. Effects of degradation. Resistance to decay. Effect of water migration in pavement structure-**1.5 hours**

Bituminous Bound Construction Materials: Flexible pavements. Asphalt, Bitumen and Tar. Types of aggregates used in bituminous composition. Desirable properties of aggregates. Influence of aggregates on engineering properties: crushing strength, resistance to abrasion, resistance to polishing, resistance to striping, resistance to weathering, ability to contribute to strength and stiffness of total mix. Detailed requirements for aggregates. Pavement distresses: Types of distresses. Roles of subgrade, structural design of pavement, selection of construction aggregates, traffic and aging in distresses-**3 hours**

Mortar and fine aggregates used in mortar: Introduction, types of mortars, description and classification of mortar sands and fillers. Types of fine aggregates used in mortars. Mineralogy of fine aggregates. Shape and grain size distribution of fine aggregates. Light weight aggregates used in mortars. Testing for fines.

Influence of sand and fines characteristics on mortar properties. UK specifications. specification and practice outside the UK-**3 hours**

Railway track ballast: Introduction. Ballast. Function of ballast. Structural elements of railway ballast. Rock types suitable for track ballast. Asphaltic track. Desirable properties: British practice. European practice-**1.5 hours**

Filter Media and Aggregates: Introduction. Principle functions of filters and drains. Key properties of filter aggregates. Testing of filter aggregates. Filter for civil engineering structures-**1.5 hours**

Large stones and Riprap: Definition of stones. Application of large stones. Application of ripraps. Desirable properties of armour stone and riprap. Rock types suitable for ripraps and armour stones, Specification. Important properties and tests: composition, physical properties. Toughness and Durability. Alteration and physical disintegration.**-3 hours**

Dimension stones: Introduction. Varieties of Dimension stones. Classification of Rock types used in Dimension stones. Surface characteristics of dimension stones. Basic Keys to selection of Stones. Rock types suitable for facing stones, flooring stones, and roofing stones. Specification-**3 hours**

Cement: Uses. Types of cements. Portland cements. Production process. Ordinary Portland cement. Portland Pozzolana Cement. Special purpose and blended cements. Other cements. Major constituents of Portland cement. Hydration of Portland cement. Composition of cement. Relative strengths of cement. Effect of cement on concrete properties. Factors affecting Strength of concretes. Specification (Clause 614) of Department of Roads-**3 hours**

Sources and field investigation of Construction Materials: Igneous, metamorphic and sedimentary rocks. Sediments (fluvial, glacial, coastal, marine, fans and talus). Residual soils. Field investigation: Prospecting (Regional geological mapping, aerial photo study). Exploration (detailed site mapping, geophysical investigation, drilling and pitting), sampling and quality assessment. Reserve estimation method.-**3 hours**

Textbooks

1. Prentice, J.E.(1990). Geology of construction materials, Champman and Hall, London, 197p.
2. Smith M. R. and Collis L. (ed.) (1993): Aggregates: sand, gravel and crushed rock aggregates for construction purposes (second edition). Geological Society Engineering Geology Special Publication, No. 9, The Geological Society, 339p.
3. Krynine, D. P. and Judd W.R. (1957): Principles of Engineering Geology and Geotechniques, John Wiley and Sons, New York
4. Johnson, R. B. and DeGraff J. V. (1988): Principles of Engineering Geology, John Wiley and Sons, New York, 497p.

Reference books

1. The complete book on construction material, NIIR Project Consultancy Services. 672p.
2. Department of Road, 2073. Standard specifications for road and bridge works. Ministry of Physical Infrastructure and Transport, Government of Nepal. 708p.
3. Bulletins of Department of Geology, Tribhuvan University, Kirtipur, Kathmandu, Nepal.
4. Journals of Nepal Geological Society, Kathmandu, Nepal.

SEMESTER: III

Course Title: Geotechnical Earthquake Engineering Full Marks: 50
Course No.: EGE624 Pass Marks: 25
Nature of the Course: Theory Credit: 2 (30 hrs)

COURSE DESCRIPTION

The course of Remote Sensing and GIS gives the necessary knowledge and skills of remote sensing inputs necessary for site investigation and evaluation for regional and local scale. It also gives knowledge of remote sensing based site selection in the feasibility stage of the project of various infrastructure development.

OBJECTIVES

General Objectives:

Provide fundamental knowledge of the nature of earthquakes, the resulting hazards and the local site effects under the earthquake ground motion. Impart basics of geotechnical earthquake engineering knowledge on description of earthquake hazards, and fundamentals of development or methods used for seismic analysis and design.

Specific Objectives:

- Provides the students with knowledge to understand the behaviour of civil engineering structures during earthquake loading.
- To familiarize the students on theory, concept and practical knowledge on strong ground motion parameters and ground response analysis
- To impart knowledge to the students on theory and concepts of seismic hazard assessment and their applications
- To make candidates able to analyse liquefaction susceptibility and seismic slope stability during seismic excitation

COURSE CONTENTS

Introduction: Introduction to Geotechnical Earthquake Engineering and Engineering Seismology, Review on Historical Development, Objective and Scope **-2 hours**

Internal Structure of the Earth: Internal Structure of the Earth, *Density* and Seismic Wave Structure inside the Earth **-1 hour**

Plate Tectonics and Global Seismicity: Plate tectonics and seismicity with special reference to earthquake generation in inter and intra-plate boundaries; *Active Tectonics of the Himalaya:* active fault systems, plate boundary fault and their earthquake potential, earthquake mechanism in the Himalaya-Tibet orogeny; *Global seismicity:* Himalayan-Alpine Belt; Circum Pacific Belt and Mid Oceanic Ridge and Significant Historical Earthquakes of the world, Pre-Historic Earthquakes, Paleoseismology and techniques to study past earthquakes.**-4 hours**

Earthquake: Definition, faulting and earthquake mechanics, Causes, Seismic Waves, Types of Earthquake, Elastic rebound Theory, Secondary hazards, Earthquake magnitude and Intensity of earthquake, magnitude conversion, Basic features: Epicenter, Epicentral Distance, Focal Depth, Focal Mechanism, Earthquake energy, Cycle, Return Period, and Frequency, Earthquake forecast and Prediction **-2 hours**

Seismic Waves: Basic Review of Elasticity: Stress and Strain, Anisotropy, Imperfect Elasticity of the Earth, Types and Characteristics of Seismic Waves, Propagation of Seismic Waves (Body and Surface) **-2 hours**

Strong Ground Motion: Introduction, Strong ground motion measurement, *Strong ground motion parameters:* Amplitude, Peak Acceleration, Peak velocity, Peak Displacement, Spectra **-2 hours**

Seismic Hazard Analysis: Earthquake catalog, Identification and Evaluation of Earthquake Sources, earthquake recurrence parameters, Ground motion prediction equations (GMPEs), Deterministic and Neo-Determinstc and Probabilistic Seismic Hazard Analyses at local, regional and global scales, Seismic hazard in Nepal Himalaya **-4 hours**

Seismic microzonation: Introduction to ambient noise (Microtremor), its measurements, Analysis, phase velocity and subsurface structure, seismic site characterization, seismic microzonation, Case histories (Nepal and Global) **-4 hours**

Dynamic Properties of Soils: Soils subjected to dynamic loading, Measurements of Dynamic Properties of Soils, Stress-strain behaviour of Cyclically Loaded Soils **-2 hours**

Site Response Analysis: Local site Effect, One and two -Dimensional Site Response analyses, Linear Approach, Non-Linear Approach, Comparison of One-Dimensional Site response Analyses Local site effects **-3 hours**

Liquefaction: Mechanism of Liquefaction, Liquefaction Susceptibility, Initiation of Liquefaction, Effects of Liquefaction **-1.5 hours**

Seismic Slope Stability: Earthquake Induced Landslide, Static Slope Stability Analysis, Seismic Slope Stability Analysis **-1.5 hours**

Ground Improvement for Remediation of Seismic hazard: Densification techniques, Reinforcement techniques, Grouting and Mixing techniques, Drainage techniques **-1 hour**

Textbooks

1. Kramer, S. L. (1996). Geotechnical Earthquake Engineering, Prentice-Hall International Series in Civil Engineering and Engineering Mechanics, Pearson Education, Inc.
2. Towhata I. (2008), Geotechnical Earthquake Engineering, Springer-Verlag Berlin Heidelberg, 684p.
3. Hiroshi Okada (Translated by Koya Suto) The Microtremor Survey method, Geophysical Monograph Series, No. 12, Society of Exploration Geophysicist, 126p.
4. Kumar K. (2008), Basic geotechnical Engineering. New Age International, New Delhi, 142 p.

Reference books

1. Day Robert W. (2002). Geotechnical Earthquake Engineering Handbook, McGraw-Hill.
2. W. Lowrie (1997). Fundamentals of Geophysics, Cambridge University Press.
3. P. Shearer (1999). Introduction to seismology, Cambridge University Press.
4. C. Scholz (2002). The Mechanics of Earthquakes and Faulting, Second Edition, Cambridge University, Press.
5. R.S. Yeats, K. Sieh. and C.R. Alien (1997). The Geology of Earthquakes, Oxford Univ. Press, pp.568.
6. Amr S. Elnashai, and Luigi Di Sarno (2008). Fundamental of Earthquake Engineering, John Wiley.
7. Bolt, B.A. (1999). Earthquakes (4^{th} Edition). W.H. Freeman and Company, New York. 366p.

SEMESTER: III

Course Title: Engineering Hydrology Full Marks: 50
Course No.: EGE625 Pass Marks: 25
Nature of the Course: Theory Credit: 2 (30 hrs)

COURSE DESCRIPTION
Surface and Groundwater Hydrology gives in-depth understanding of movement of water on surface and subsurface of the earth. It also provides the essentials for exploration, drilling, development, and management of groundwater.

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

- Stream flow and discharge,
- Runoff and subsurface flow,
- Various applications of hydrology.
- Groundwater exploration,
- Well hydraulics, well design, well drilling, and development techniques, and
- Groundwater monitoring.

COURSE CONTENTS
ENGINEERING HYDROLOGY
Stream Flow. Water stage, manual and automatic river gauges, crest stage gages, selection of river gauging station site, methods of river discharge measurement, development of rating curve-**2 hours**

Evapo-Transpiration. Reservoir evaporation estimation from pan evaporation and related meteorological data, Factors affecting transpiration, determination of evapo-transpiration, estimating potential evapo-transpiration from meteorological data, irrigation water requirements, controlling evapotranspiration.-4 **hours**

Precipitation and Runoff. The phenomena of runoff, surface retention, runoff mechanisms, estimating the volume of storm runoff from average rainfall over a basin, factors affecting total storm runoff, infiltration approach to runoff estimates, infiltration indexes, estimating snowmelt runoff, seasonal and annual runoff relations, precipitation runoff relations-**6 hours**

Hydrographs Analysis. Characteristics of a flood hydrograph, hydrograph separation, analysis of complex hydrographs, determination of total basin runoff, the unit hydrograph concept, derivation of unit hydrographs from complex storms, conversion of unit hydrograph duration, engineering application of unit hydrographs-**6 hour**

Hydrological Routing: Wave movement in natural channels, the storage equation, determination of storage, treatment of local inflow, reservoir routing, channel routing, deriving basin outflow by routing-**4 hours**

Probability in Hydrology. Return period concept, data sources for probability analysis, empirical methods of flood estimation, theoretical distributions of flood, Gumbel distribution, Log-Pearson type III distribution, Log-normal distribution, plotting positions, flow duration curve, selection of design frequency based on acceptable risk, development and use of IDF curve from fixed interval precipitation data, design storm-**6 hours**

Application of hydrology. Application of hydrology in infrastructure development projects**,** disaster risk management, agricultural productivity enhancement, urban storm water management, water supply,

reservoirs, flood regulations, channel improvement for flood mitigations, flood plain mapping, highway, culverts and side drain, spillway design, types of data requirement for application of hydrology-**4 hours**

Textbooks

1. Fetter, C. W., (1990). Applied Hydrogeology, 2nd ed., CBS Publisher India.
2. Todd, K. D. (1980). Groundwater Hydrology 2nd ed., John Wiley &Sons Inc., New York
3. Subramanyan, K. (1994). Engineering Hydrology.
4. Linsley, R.K.,Kohler M.A. and Paulhus J.L.(1994). Hydrology for engineers. Mcgraw Hill Kogakusa Ltd. Japan.

Reference books

1. Driscoll, F. G. (1989). Groundwater and Wells, Johnson Filtration Systems lnc., Minnesota
2. Raghunath, H. M (1992). Groundwater (2nd ed), Wiley Eastern Limited, New Delhi, India.
3. Jones, G. P. and Rushton, KR. (1981). Pumping-test analysis, Groundwater Resources Evaluation (Lloyd)
4. Garg, S. P. (1982). Groundwater and Tubewells (2nd ed.), Oxford and IBH publishing Co. Ltd. New Delhi.

SEMESTER: III

Course Title: Hydropower Engineering Full Marks: 50
Course No.: EGE626 Pass Marks: 25
Nature of the Course: Theory Credit: 2 (30 hrs)

Introduction. *Hydropower development:* historical background, present and future development. Power situation in Nepal and world: thermal power, geothermal power, water and electrical power, and their development Sources of hydropower potential: Definition and types; surface flow; ground water and oceans; gross, technical and economical potentials. Hydropower plants: types and classification based on energy, storage capacity and head; pump storage plant

Power Regulation. *Definition:* energy mix and its importance, primary and secondary power, plant and installed capacity; mean and peak load; load curve, load capacity, utilization and diversity factors. Power variation: daily, weekly, monthly and annual variations or power. Power grid: introduction and components of power system.

Hydropower Projects Planning
Site Selection: reconnaissance, hydrological, geological and detailed investigations. Requirements for hydropower: flow duration curves, mass curves of flow and their uses, energy flow diagram, gross and net head, power estimation, its demand and prediction. Reservoir regulation: peak and normal flow discharges, distribution of sediments and their control, life of reservoirs. General layout of hydropower projects: storage, diversion and pump storage types with intake, forebay, surge tanks, penstock, powerhouse, supply conduit, casing, draft tube and tailrace. canal.

Retaining Structure for Water
Dams: classifications based on function and head; forces acting on dams. Materials for dams: earth soil, boulder, rock and concrete. Site selection for dams: available materials, topography, economy, etc. Foundation treatment: types of grouting and their necessity; remedies against piping and exit gradient. Design of concrete gravity dams; safety factor against overturning, sliding, floating, free-board. Design of earthen dams: general considerations; safety, factor against slope stability; phreatic line, seepage flow discharge.

Regulating Structures
Intake: importance, location and types; design of intake structures. Hydraulic tunnels: definition; rock pressure, hardness coefficient of rocks; pressure and non-pressure tunnels, their types and design; headloss in pressure tunnels; design of tunnel lining. Settling basin: characteristics of suspended sediments-settling velocity, horizontal velocity and lifting velocity; types of settling basin and its location, settling basins with periodical and continuous flushing; components of basins and their designs. Forebay and surge tanks: importance, location condition of their application, and design of forebay structure. Penstock liners: importance, location, condition of their application; hydraulic hammer; hydrodynamic pressure calculation; turbine head and determination of penstock diameter

Spillways
Design of spillway: definition, purpose, types, design specifics; types of gates and their location; occurrence of cavitation and cavitation erosion. Energy dissipation: types of energy dissipators and their necessity; role of tail-water depth. Design of stilling basin.

Hydro-Electrical Machines
Hydro-mechanical installation: turbines - Pelton, Francis, Kaplan and their performance characteristics; selection of turbines and their specific speed; introduction to bulb turbine; draft tube, tailrace canal and their importance. Pumps-centrifugal, reciprocating and their performance

characteristics, selection and starting speed.

Electro-Mechanical Installation
Generators and their types; purpose and working principle of governors, classification and dimensions of powerhouse.

Micro-Hydro and Mini-Hydro Systems
Basic concepts, suitability in national context, types of units, design and selection considerations, pumps as turbines, institutional consideration.

Environmental, Social and Political Feasibility of Hydropower
Preliminary questions, checklist of consideration, evaluations methodologies, social and political consideration.

Economic Analysis for Hydropower
Introduction and theory, methodology for analysis, other economic considerations, cost estimation, application of analysis, financial consideration.

Performance characteristics of a Pelton and Francis turbines.
Characteristics of Kaplan turbine, open channel flume, centrifugal pump, pressure channel flume

Assignments on numerical problems.

Textbooks
1. Warnick, C. C., (1984). Hydropower Engineering, Prentice-Hall. Inc., New York, USA.
2. Grishin, M. M. (1982). Hydraulic Structures, Mir Publishers, Moscow.
3. Varshney, R. S. (1986). Hydropower Structures, Nem Chand and Bros., Roorkee.

SEMESTER: III

Course Title: Numerical Modelling Full Marks: 50
Course No.: EGE627 Pass Marks: 25
Nature of the Course: Theory Credit: 2 (30 hrs)

COURSE OBJECTIVES

The objectives of the course are:

- to introduce basic concepts of numerical modelling and its importance and challenges with some examples in the field of engineering geology.
- to make students familiar with some software packages and tool kits used to implement the different numerical algorithms in scientific computing.
- to provide students with up-to-date knowledge on some numerical methods and techniques.
- the students will be given opportunity to develop numerical schemes to solve ordinary differential equations (ODE) using computer program.
- to introduce basic concepts of Finite difference method (FDM) and Finite element method (FEM) for three different type of partial differential equations PDEs to solve numerically by using computer program.
- Students will developed the skill to visualize the numerical solution graphically and compare with exact solution
- at the end of the course the students will gain sufficient knowledge to do numerical analysis and to write computer programs for real life problems.

COURSE CONTENTS

Numerical Modelling, Introduction to Programming, Programming Environment, Control Statement: Conditional Statements, Repetition Statements, Programming, Debugging, Numerical Linear Algebra, Numerical Integration (Trapezoidal Rule, Simpson Rule), Numerical Solutions Initial Value Problem (Ordinary Differential Equations (ODE)), Numerical solution of sets of first order ODEs, Explicit and implicit Euler and Runge-Kutta methods for solving ODEs, Introduction to Finite Element Method (FEM), Ritz-Galerkin Method.

DETAILS COURSE CONTENTS

1. Introduction to Computer Programming -6 hours

Introduction to Programming: Components of a computer, Working with numbers, Machine code, Software hierarchy

Programming Environment: Programming Windows, A First Program, Expressions, Constants, Variables and assignment statement, Built in functions, Hierarchy of arithmetic operations, Arrays, Relational and logical operations.

Plotting: Basic plotting, 2-D plotting, Multiple plot, Subplot, fplot, 3-D plotting, Formatting the plot, *Computer Programming Exercises.*

2. Control Statement and Programming -5 hours

Conditional statements: Branches: If construct, Nested if construct, the switch construct, try/catch construct, **Repetition statements: Loop:** While loops, For loops, Nested for loop, Break, Nested Break, Continue, Error.

Programming: Some remarks about Variables, Writing programs, Programming language constructs, Creating programs, Writing to a text file, Reading from a text file, Randomising and sorting a list, Searching a list, Structure variables, *Computer Programming Exercises.*
Debugging: **Various Kinds of Computing Errors**, Possible Issues for debugging, Minimizing bugs.

3. **Numerical Linear Algebra and Numerical Integration -5 hours**
   Numerical Linear Algebra: Review of Matrices, Entering matrices, Matrices with symbolic elements, Entering vectors, Special matrices, Indices, Matrix operations using computer program, Solving sets of linear equations by using Gauss's elimination method Gauss-Seidel method, *Computer Programming Exercises.*

   Numerical Integration: Trapezoidal rule, Simpson 1/3 Rule, Simpson 3/8 Rule, *Computer Programming Exercises.*

4. **Numerical Solutions of IVP Ordinary Differential Equations (ODE) -5 hours**
   Review of ODEs, direction field and exact solution. Plotting of the direction field and the integral curves of ODEs. Explicit and implicit Euler and Runge-Kutta methods for solving ODEs, *Computer Programming Exercises.*

5. **Finite Element Method -5 hours**
   Introduction to Finite Element Method, Weak Form of PDEs, Stiffness Matrix and, Ritz-Galerkin Method (approximate function, Galerkin Method and Ritz Method), Construction of approximate function, *Computer Programming Exercises.*

6. **Numerical Modelling -4 hours**
   Introduction of Numerical Modelling, Components of Numerical Modelling, Importance and Challenges of Numerical Modelling with some examples in the field of engineering geology.

Project works. A project work in software to solve an engineering geological problem such as, slope stability, landslide hazard analysis, rockmass rating, tunnel over breaks.

Textbooks and Reference Books

1. Yang WY, Cao W, Chung T-S, Morris J (2005) Numerical Methods Using MATLAB, A John Wiley & Sons, Inc., Publication
2. Thomas JW (1998) Numerical Partial Differential Equations: Finite Difference Methods, Springer, New work.
3. Reddy JN (1993). An Introduction to The Finite Element Method, Second Edition, McGraw-Hill, New York
4. Burden RL, Faires JD (2011) Numerical Analysis, Ninth Edition, Brooks/cole Cengage Learning.
5. Chandrupatla TR, Belegundu AD (2002). Introduction to Finite Elements in Engineering. Prentice Hall
6. MATLAB User's Guide, The MathWorks, Inc. USA
7. MATLAB Reference Guide, The MathWorks, Inc. USA
8. MATLAB External Interface Guide, The MathWorks, USA
9. Interactive Matlab Course, Endhoven University of Technology, 190 p.

SEMESTER: III

Course Title: Practical I: Engineering Drawing and Surveying Full Marks: 25
Course No.: EGE628 Pass Marks: 12. 5
Nature of the Course: Practical Credit: 1 (45 hrs)

COURSE DESCRIPTION

Students will learn the concepts of sketching, drafting skills and make familiar with standard symbols of different engineering fields to understand the engineering drawings.

General Objectives. The course aims to develop basic concepts on projection with reference to points, lines, planes and geometrical solids and to make familiar with the conventional practices of sectional views and software uses.

COURSE CONTENTS

1. Drawing Sheet Layout, Freehand Lettering, Sketching of parallel lines, circles, Dimensioning
2. Applied Geometry (Sketch and Instrumental Drawing)
3. Projection of Point, Lines and Planes (Sketch and Instrumental Drawing)
4. Applications in Three dimensional Space (Sketch and Instrumental Drawing)
5. Multiview, Sectional Drawings, Auxiliary Drawings and Dimensioning (Sketch and Instrumental Drawing)
6. Conventional Practices for Orthographic and Sectional Views (Other Type Sections)
7. Development and Intersection
8. Isometric Drawing (Consisting of Curved Surfaces and Sections)
9. Oblique Drawing
10. Perspective Projection
11. Familiarization with Graphical Symbols (Symbols for Different Engineering Fields)
12. Introduction to Working Drawing, Detail Drawing, Assembly Drawing
13. Introduction to Chain Survey and Leveling
14. Application of Theodolite and Total Station on Field
15. Autocad basics to develop the topographical maps

Textbooks and reference books

1. W J Luzadder and J M Duff, Fundamentals of Engineering Drawing, 11th edition, Prentice-Hall of India, 2015. 704p
2. French, Thomas Ewing, Charles J. Vierck, and Robert J. Foster. Engineering Drawing and Graphic Technology. New York: McGraw-Hill, 1993. 745p
3. Frederick E. Giesecke, Ivan L. Hill, Henry C. Spencer, Alva E. Mitchell, John Thomas Dygdon, James E. Novak, Shawna E. Lockhart, Marla Goodman. Technical Drawing with Engineering Graphics. Peachpit Press, 14th Edition, 2011, 936p
4. N.D. Bhatt, V.M. Panchal, Machine Drawing, Charotar Publishing House, 49th Edition, 2014, 376p
5. P. S. Gill, A Textbook of Machine Drawing, S. K. Kataria and Sons,2013 Edition, 700p
6. Surveying – A. Banister and S. Raymond, ELBS
7. BC Punmia – Surveying, Laxmi Publication, New Delhi

SEMESTER: III

Course Title: Practical II: Construction Material Engineering Full Marks: 25
Course No.: EGE629 Pass Marks: 12. 5
Nature of the Course: Practical Credit: 1 (45 hrs)

COURSE CONTENTS

Lab 1: Testing of coarse aggregates for grading.
Lab 2: Testing of fine aggregates for grading and fineness modulus.
Lab 3: Description of physical characteristics and classification of stones and aggregates. Specification of construction aggregates of Department of Road: Section 600: Materials and Testing materials. Clauses 609, 610, 611, 612, 613, 614; Section 1200: Subbase, base and wearing course: Clauses 1201 (1), (2) and (3); 1202 (1), (2) and (3); 1203 (1), (2) and (3); 1204 (1), (2) and (3); 1207 (1), (2) and (3); 1208 (1), (2) and (3); Section 1300: Bituminous surface and base course: Clauses 1303 (1) and (2b); 1304 (1) and (2); 1305 (1) and (3); 1306 (1) and (3); 1307 (1), (2a), (2b) and (2c); 1308 (1) and (2a to 2d); 1309 (1) and (2); 1310 (1) and (2); 1311 (1) and (2); 1313 (1), (2) and (3); 1314 (1), (2), (3a) and (3b); 1315 (1) and (2); 1316 (1) and (2a to 2e).
Lab 4: Determination of shape indices and texture of coarse aggregates.
Lab 5: Physical testing of coarse aggregates for specific gravity and water absorption.
Lab 6: Physical testing of fine aggregates for specific gravity and water absorption.
Lab 7: Sample preparation for aggregate crushing and impact values.
Lab 8: Determination of aggregate crushing and impact values.
Lab 9: Sample preparation for testing for abrasion resistance and durability.
Lab 10: Testing of aggregates for Los Angeles Abrasion Value.
Lab 11: Testing of aggregates/rock samples for slake durability.
Lab 12: Testing of mechanical strength of samples of construction material.
Lab 13: Determination of deleterious constituents and micropetrographic index for given rock/particle types.
Lab 14: Methylene blue adsorption value of rocks and aggregate samples.
Lab 15: Reserve estimation of construction material.

Text and Reference Books

1. Prentice, J.E.(1990). Geology of construction materials, Champman and Hall, London, 197p.
2. Smith M. R. and Collis L. (ed.) (1993): Aggregates: sand, gravel and crushed rock aggregates for construction purposes (second edition). Geological Society Engineering Geology Special Publication, No. 9, The Geological Society, 339p.
3. Johnson, R. B. and DeGraff J. V. (1988): Principles of Engineering Geology, John Wiley and Sons, New York, 497p.
4. The complete book on construction material, NIIR Project Consultancy Services. 672p.
5. Department of Road, 2073. Standard specifications for road and bridge works. Ministry of Physical Infrastructure and Transport, Government of Nepal. 708p.
6. Various test specifications of ASTM, BS and IS.
7. Bulletins of Department of Geology, Tribhuvan University, Kirtipur, Kathmandu, Nepal.
8. Journals of Nepal Geological Society, Kathmandu, Nepal.

SEMESTER: III

Course Title: Practical III: Slope Stability and Landslide Engineering Full Marks: 25
Course No.: EGE630 Pass Marks: 12. 5
Nature of the Course: Practical Credit: 1 (45 hrs)

COURSE CONTENTS

1. Slope stability analysis using method of slices, Limit Equilibrium Method
2. FEM Analysis of Slopes, Computer Analysis with available Computer Programs
3. Slope Seepage Analysis
4. Slope stabilization Methods: Retaining Walls, Check dams, Bioengineering
5. Landslide classifications and nomenclatures
6. Landslide inventory and mapping of causative factors
7. Project work on the success stories of landslide mitigations in Nepal and in international level
8. Landslide susceptibility and hazard assessment using GIS: Heuristic qualitative approach and statistical quantitative approach, Validation of hazard maps
9. Landslide Vulnerability and Risk assessment
10. Kinematic Analysis of rock slopes, application of RMR and SMR

Text Books

1. Lee W. Abramson, Thomas S. Lee, Sunil Sharma and Glenn M. Boyce (2002), Stability and Stabilization Methods, John Wiley & Sons, Inc., 712 p.
2. Duncan C. Wyllie and Christopher W. Mah (2004), Rock Slope Engineering (Civil and mining), Spoon Press, 431 p.
3. A. K. Turner and R. L. Schuster (1996), Landslides: investigation and mitigation, National Academies Press, 673 p.
4. E. M. Lee and D. K. C. Jones (2004) Landslide risk assessment, Thomas Telford Limited, 454 p.

Reference Books

1. J. Michael Duncan and Stephen G. Wright (2005), Soil Strength and Slope Stability, John Wiley & Sons, Inc., 280 p.
2. Y.M. Cheng and C.K. Lau (2008), Slope Stability Analysis and Stabilization (New methods and insight), Routledge, 241 p.
3. Denys Brunsden and David B. Prior (editor) (1984), Slope Instability, John Wiley & Sons, Inc., 620 p.
4. Landslide Risk Assessment (2005), Oldrich Hungr, Robin Fell, Rejean Couture, Erik Eberhardt (editors), Taylor and Francis, London, 771 p.
5. Landslide Hazard and Risk (2005), Thomas Glade, Malcolm Anderson, Michael J. Crozier (Editors), John Wiley & Sons Ltd, England, 802 p.
6. Manuals of software and published papers

SEMESTER: III

Course Title: Practical IV: Geotechnical Earthquake Engineering Full Marks: 25
Course No.: EGE631 Pass Marks: 12. 5
Nature of the Course: Practical Credit: 1 (45 hrs)

COURSE CONTENTS

1. **Seismic hazard assessment**: fault rupture, ground shaking, and probabilistic and deterministic seismic hazard assessment.

a) To determine the earthquake magnitude using fault rupture data
b) To compute seismic hazard using deterministic approach
c) To interpret results of probabilistic seismic hazard assessment of different scales

2. **Estimating ground motion parameters:** Evaluation of the ground motion parameters.
   a) To determine and interpret strong motion parameters by analysing acceleration time history of Himalayan and other region major earthquake events
3. **Ground response analysis:** Site effects, 1D ground response analysis (Linear and non-linear)

a) To interpret dynamic properties of different types of soil
b) To assess the local site effects using 1D ground response analysis
c) To assess local site effects by analysing strong ground motions measured at rock and soil sites

4. **Identification, assessment and mitigation of liquefaction hazards**: Assessment of liquefaction susceptibility
   a) To assess liquefaction susceptibility of given soil column using different earthquake scenario.

Text book

1. Kramer, S. L. (1996). Geotechnical Earthquake Engineering, Prentice-Hall International Series in Civil Engineering and Engineering Mechanics, *Pearson Education Inc.*,
2. Towhata I. (2008), Geotechnical Earthquake Engineering, *Springer-Verlag Berlin Heidelberg*, 684p.

Reference book

1. Kumar K. (2008), Basic geotechnical Engineering. New Age International, New Delhi, 142 p.
2. New Zealand Geotechnical Society (2010), Geotechnical earthquake engineering practice Module 1 – Guideline for the identification, assessment and mitigation of liquefaction hazards.

SEMESTER: III

Course Title: Practical V: Engineering Hydrology Full Marks: 25
Course No.: EGE632 Pass Marks: 12. 5
Nature of the Course: Practical Credit: 1 (45 hrs)

COURSE CONTENTS

Lab 1: Measurement and estimation of precipitation; Precipitation gage network and data acquisition; Interpretation of precipitation data; Preparation of maps of drainage basins using Isohyatal method and Theissen polygon method. 9 hours
Lab 2: Estimating evaporation and evapotranspiration 3 hours
Lab 3: Plotting hydrographs, Hydrograph analysis, Estimating storm runoff and snowmelt runoff. 6 hours
Lab 4: Determination of storage, Estimating water balance in a drainage basin 3 hours
Lab 5: Flood frequency analysis using gage station data from the major rivers of Nepal (Data from Department of Hydrology and Meteorology); Log Pearson III method, Gumbel Method 6 hours
Lab 6: Numerical and kinematic techniques of hydraulic routing 3 hours
Lab 7: Problems related to well hydraulics 3 hours
Lab 8: Preparation of hydrogeological maps 3 hours
Lab 9: Analysis of pumping test data, acquisition and interpretation of groundwater monitoring data. 6 hours
Lab 10: Interpreting remote sensing and geophysical well logged data in exploration of groundwater. 3 hours

Textbooks

1. Fetter, C. W. (1990). Applied Hydrogeology, (2nd ed.), CBS Publisher India.
2. Todd, K. D. (1980). Groundwater Hydrology (2nd ed), John Wiley &Sons Inc., New York.
3. Subramanyan, K. (1994): Engineering Hydrology.

Reference books

1. Linsley, R.K.,Kohler M.A. and Paulhus J.L.(1994). Hydrology for engineers. Mcgraw Hill Kogakusa Ltd. Japan.
2. Driscoll, F. G.,(1989). Groundwater and Wells, Johnson Filtration Systems lnc., Minnesota
3. Raghunath, H. M (1992). Groundwater (2nd ed), Wiley Eastern Limited, New Delhi, India.
4. Jones, G. P. and Rushton, KR. (1981). Pumping-test analysis, Groundwater Resources Evaluation (Lloyd)
5. Garg, S. P. (1982). Groundwater and Tubewells (2nd ed.), Oxford and IBH publishing Co. Ltd. New Delhi.

SEMESTER: III

Course Title: Field works Full Marks: 50
Course No.: EGE633 Pass Marks: 25
Nature of the Course: Field works Credit 2 (15 days)

COURSE DESCRIPTION
Basic knowledge on engineering geological investigation and evaluation.

OBJECTIVES
General Objectives: To provide the students some background knowledge of geological and engineering geological mapping and preparing engineering geological map, crossections, and data acquiring through field testing of soils and rocks. Students also do engineering geological study of hydropower project and prepare a brief report. Students also learn landslide inventory and process of underground construction.

Specific Objectives: Learn geological mapping, engineering geological mapping, field testing of soils and rocks, methods of collection of geomorphological, hydrological and geotechnical data and preparation of engineering geological map and present in a GIS based format. Learn geological hazard mapping and data collection.

COURSE CONTENTS
Each student will conduct geological and engineering geological study focusing on a specific project assigned by field supervisor(s) and with prior approval by the department. Student also prepare a specific project report on the available one or more topics such as geological, engineering geological site investigation, slope stability, landslide engineering, tunnel engineering, hydropower engineering and hydrogeological information etc. related with engineering geological project along with field visit to validate the collected data. A final project report with collected data sheets, analysis and interpretation in a given format will be submitted to the department by individual student and make formal presentation as part of the examination.

SEMESTER: IV

SEMESTER: IV

Course Title: Engineering Project Management Full Marks: 50
Course No.: EGE661 Pass Marks: 25
Nature of the course: Theory Credit 2 (30 hours)

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.

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

Specific Objective. To provide the students with the understanding of Project evaluation and selection, Organising and staffing, Project planning, and Project implementation.

COURSE CONTENTS

Unit –I Introduction of Project Management -**5 hours**

Understand what a project is and, what it is not. Definition of a Project, Project Characteristics, Project Attributes, Concept and application of PMBOK, The Process of Project Management, Understanding project management: projects in contemporary organization, Project Management Expertise: Application knowledge, Understanding the Project Environment, Assess the environment, Management Knowledge and Skills, Interpersonal Skills: communication, Influence, leadership, motivation, negotiation, problems solving, The Project Life Cycle (Phases): Initiation Phase, Planning Phase, Implementation (Execution) Phase, Closing Phase, Project, Charter Project

Unit -II: Project Organization -**5 hours**

The project office and the team, the project manager and his role and responsibilities, essence of a project manager (skill requirements), selecting the project manager, the project organisation, preparation and selecting an appropriate project organization-structure, leadership and establishing the Organizational Breakdown Structure (OBS) for the project. Project information-transfer needs (i.e., who needs information from whom), project teams: team building in the project environment and reporting structure, Training and Technology transfer.

Unit III: Project Planning and Scheduling -**10 hours**

Definition of Project planning, project planning and its elements, Planning phase, Criteria for project selection, the nature of project selection, types of project selection, project risk analysis, internal rate of return (IRR), FIRR, EIRR, net present value, sources of information for project evaluation- selection,.
Activities of Project, Establishing the Work Breakdown Structure and mapping this structure to the established OBS, Linear responsibility charts, interface management Developed Project budget and Cost Breakdown Structure and mapped to the OBS and WBS. Action plan WBS and timeline of the project, resource constraints. schedule, budget, pricing and cost estimation, cost control, cash flow, estimating pitfalls, quality and environment, project proposals and funding
Scheduling. Introduction, Network techniques: PERT and CPM. Qant Charts, other conventional presentation techniques, time extensions and applications. Resource allocation: critical path method, the resource allocation problem, resource loading, resource levelling, constrained resource scheduling, multi-project scheduling and resource allocation.

Unit -IV: Project Implementation - **4 hours**

Develop and finalized legal documents for implementation, Develop project critical success factors. Negotiation 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, the low bidder dilemma, contract variation, amicable settlement, **Budget release**, Project Monitoring system, corrective action in project progressing according to scope, product performance, project schedule, project budget, to keep a project on track. Earned Value Analysis, Reports are based on the organization and established reporting structure.

Unit-V: Project monitoring and Control and Monitoring – **5 hours**

Project monitoring, Information collection from different responsibilities center, project scope, Project Monitoring system, and corrective action in project progressing according to scope, product performance, project schedule, project budget, to keep a project on track when and how changes are made to baselines. Earned Value Analysis, Project monitoring and management information systems (PMIS). Information needs and reporting, PMIS requirements, 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.

Unit-VI: Project Learning (Project base Learning) -**1 hour**

Project Learning is recognized by organizations as one of the most important factors for success in current and future projects. Through life-cycle and post-mortem analysis, the project manager may identify areas to be emphasized or more closely managed in future projects. In this section students will developed a hypothetical project and practice all of the components. Such areas include:

- Project selection, evaluation
- Resource allocation,
- Risk and uncertainty,
- Budget constraints,
- Project feasibility, and
- Change management.

System Dynamics simulation methodology for evaluating certain performance parameters of a project.

Textbooks

1. Meredith , J. and Mantel, S. J. (1989). Project Management - A Managerial Approach. J Wiley, New York.

Reference books

Krezner H. (1987).Project Management - A System Approach in Planning, Scheduling, and Controlling.
Heagney J.(2011). Fundamental of Project Management, Fourth Edition American Management Association
Richardson G.L and Jackson B.M.(2019). Project Management Theory and Practice, Third Edition, CRC Press. Taylor & Francis Group, New York

SEMESTER: IV

Course Title: Seminar (Proposal and Paper Writing) Full Marks: 25
Course No.: EGE662 Pass Marks: 12.5
Nature of the Course: Assignments and Presentation Credit: 1 (15 hrs)

OBJECTIVES

The overall objectives of this course are

- To know the process of literature review for academic research
- To know the methods of proposal writing for academic research
- To know the methods of scientific paper writing
- To enhance the skill of academic presentations

COURSE CONTENT

The students will be provided the guidelines on the literature review process and its importance for the academic as well as scientific proposal writing. They will be provided with the guidelines and methods of academic proposal writing as well as scientific paper writing. Each student will be assigned topics for literature review, academic proposal writing and scientific paper writing. The topics should be on ongoing and other prominent engineering geological issues in Nepal. Students will complete it and they have to present it in front of faculties; and the assigned teacher/s will evaluate the work/ presentation based on the quality of the assignment done by the student, handling of questions and level of presentation.

SEMESTER: IV

Course Title: Dissertation Full Marks: 100
Course No.: EGE663 Pass Marks: 50
Nature of the Course: Field and lab works (Credit 4)

COURSE DESCRIPTION

Dissertation work is an important component of the curriculum of engineering geology. Major emphasis is given to this course with 4 credit hours. It provides students an opportunity to test their knowledge and skills that they have learnt during the entire course. Dissertation is based on both field and laboratory works. However, the proportion of field and lab-work may vary depending upon the type of project selected.

OBJECTIVES

General Objectives. To train students to be able to work independently from the stage of project formulation, planning, develop research methodology, field laboratory work and compile and integrate the result, prepare the dissertation and finally present the research work before the examiners and general audience.

Specific Objectives. To test the knowledge and skill of the students in planning and successful completion of the engineering geological research. Carryout field and laboratory tests, Report writing skills and presentation.

COURSE CONTENT

Before the start of the dissertation work, the students must prepare a research proposal and submit to the department through the assigned supervisor/s and make presentation before the expert panels appointed by the department. Once the proposal is accepted by the department, the student can start the work under the guidance of the assigned supervisor. The research component must include both fields as well as laboratory works. The final dissertation must be approved and signed by the supervisor before it is submitted to the department for evaluation. Evaluation will be based on the level of field and laboratory work, content, quality of write up and presentation. The work will have to be presented at the department to a wider audience. Two expert panels will evaluate the dissertation work.

SEMESTER: IV

Course Title: Elective -Climate Change and Disaster Risk Management Full Marks: 50
Course No.: EGE664 Pass Marks: 25
Nature of the course: Theory Credit 2 (30 hours)

GENERAL OBJECTIVE

To produce competent professionals on climate change and Disaster Risk Management with a solid and holistic interdisciplinary background so that they can understand and act on the complex context of acting and working before, during and after a disaster.

SPECIFIC OBJECTIVES:

To provide knowledge on climate change and its impact, adaptation and mitigation

To provide knowledge and principles of natural hazard and disaster risk management

To provide knowledge on methods of specific disaster mitigation measures

The overall objectives of this course are

- To provide the concept of climate change and its impact, adaptation and mitigation
- To provide the knowledge on context of climate change trend and scenario in Nepal
- To provide the knowledge on major geo-hazards and details on disaster risk management
- To provide the Nepalese context of disaster risk reduction and management

COURSE CONTENT

Unit 1: Introduction-2 hours

Global warming and climatic variability, concept of climate change, driving mechanisms of climate change, methods of paleoclimate reconstruction, observed and projected global climate change, climate change trend and scenario in the Nepal Himalaya, climate modelling.

Unit 2: Climate Change Impacts and Vulnerability in the Nepal Himalaya-4 hours

Climate change and geological processes; climate change impacts on: transportation and infrastructures sectors, water resource and energy sector, food security sector, ecosystem and biodiversity sector, human health sector; vulnerability assessment methods and mapping, sectoral and geographical vulnerability assessment of Nepal, case studies on impact and vulnerability of climate change in Nepal.

Unit 3: Climate Change Mitigation and Adaptation-6 hours

Concept of adaptation and mitigation, sectoral mitigation approaches: energy, transportation, buildings, industry, agriculture, livestock, forest and waste management; adaptation approaches: planned and self-adaptation measures, adaptation strategies; sectoral adaptation: agriculture and food security, water resource and energy, human health, biodiversity, settlement and infrastructure, tourism, transportation, nexus among adaptation, sustainable development in the context of climate change.

Unit 4: Climate change and disaster -3 hours

Relation of climate change with disaster, gender issue in disaster, water crisis as a consequence of climate change, desertification.

Unit 5 : Disasters in Nepal-6 hours

Geo-hazards, hydro-meteorological hazards and other hazard potential in Nepal, concept of hazard and disaster, historical records and scenario of spatial and temporal disaster distribution in Nepal, causes and mitigation measures of hydro-meteorological and geological disasters in Nepal, spatial distribution of disasters within different morphotectonic zones of Nepal, Climate change induced disasters, documentation of disaster events in Nepal, stakeholders for DRR in Nepal, assignments and case studies.

Unit 6: Evolution of Disaster Risk Management-6 hours

Concept of disaster risk reduction and disaster risk management, evolution of DRM, DRM cycle, comprehensive disaster risk reduction approach, use and application of emerging technologies (GPS, RS, GIS), disaster response plan, co-ordination of stakeholders before, during and after disaster, community based disaster risk management, participatory disaster risk assessment, monitoring and evaluation of disaster.

Unit 7: Legislations on Disaster Risk Management-3 hours

Disaster Risk Management (DRM) in Nepal constitution, Disaster Risk Reduction and Management Act 2017; Natural calamity act 1982, DRM in Periodic Plans, National strategy of disaster Risk Management, Hygo framework of Action, International legal provisions and experience; role of National Disaster Risk Reduction and Management Authority in disaster management in Nepal.

Texbooks

1. Wishner, B. Blaikie, P. Cannon, T. & Davis, I. (2004). At Risk: Natural Hazards, People's Vulnerability and Disasters, 2nd edition, Routledge
2. Bryant E. (2005). Natural Hazards, Cambridge University Press UK.
3. Keller, A. E (1985). Environmental Geology, CBS Publishers and Distributors, Delhi, India.
4. Kreimer, A., Arnold, M. (2000). Managing disaster risk in emerging economies, World Bank Publcations
5. Kreimer, A; .Arnold, M. & Carlin, A. (2003). Building safer cities: The Future of Disaster Risk, the World Bank
6. Government of Nepal (2008). National Strategy for Disaster Risk Management

References

1. MOE (2010). National Adaptation Plan of Action (NAPA). Kathmandu: GoN
2. MoE (2010). Climate Change Vulnerability Mapping for Nepal, Government of Nepal, Ministry of Environment.
3. MoHA (1996). National Action Plan on Disaster Management in Nepal, 1996. Kathmandu: HMG, Ministry of Home Affairs.
4. NSET (2008). National Strategy for Disaster Risk Management in Nepal (Final Draft), submitted to UNDP Nepal by the National Society for Earthquake Technology – Nepal.
5. Practical Action (2009). Temporal and Spatial Variability of Climate Change over Nepal (1976-2005), Practical Action Nepal Office
6. Pradhan B. K. (2007). Disaster Preparedness for Natural Hazards: Current Status in Nepal, Kathmandu: ICIMOD (International Centre for Integrated Mountain Development).
7. UNDP (2009). Nepal country report, Global Asessment of Risk.

SEMESTER: IV

Course Title: Elective-Landfill Engineering and Solid Waste Management Full Marks: 50
Course No: EGE665 Pass Marks: 25
Nature of the Course: Theory Credit: 2 (30 hrs)

COURSE DESCRIPTION

The students will learn the basic knowledge on selection and geological/geotechnical investigation of engineered landfill sites and solid waste management.

OBJECTIVES

General Objectives. To provide basic knowledge on geological/geotechnical investigation of engineered land filled sites and landfill site management.

Specific Objectives

To provide the students with in-depth knowledge of Parameters required in selecting landfill site, Landfill site management; and Government's related rules, regulations and policies.

COURSE CONTENTS

Landfill site selection criteria/parameter for different geological conditions, leachet management technique, gas collection and treatment (including energy recovery), monitoring and utilization of closed landfill sites (use of old landfill sites for recreational purposes / other additional purposes), influence of pre-treatments measures on the emission, mineral liner characteristics/ alternative techniques, surface and sub-surface water management techniques, groundwater quality monitoring tools (groundwater management), soil erosion control in and around landfill site, engineered landfill sites selection and criteria for different geologic zones in Nepal rules, regulation, guidelines and laws in Nepalese context / cases of other countries.

REFERENCE BOOKS

1. George Tchobanoglous, Hilary Theisen & Samuel Vigil (1993). Integrated Solid Waste Management, *McGraw Hill-intl. edition*

SEMESTER: IV

Course Title: Elective -Environment Assessments of Engineering Project Full Marks: 50
Course No: EGE 666 Pass Marks: 25
Nature of the Course: Theory Credit: 2 (30 hrs)

COURSE DESCRIPTION

Monitoring and evaluation of a Project and EIA/IEE are essential to improving project effectiveness. Effective environment impact assessment as required and outlined by the National Environmental Policy Act and Regulations, and project monitoring allow a project team to make appropriate decisions on a day-to-day basis and ensures that projects are carried out as planned and modified when necessary.

OBJECTIVES

General Objectives.

To equip students with in-depth knowledge of environmental impact assessment and to determine the best strategies for achieving the project objectives.

Specific Objectives.

To enable the students to receive in-depth knowledge of

The crux and concept of effective project monitoring and evaluation Strategies and techniques for monitoring and evaluating projects

Preparation monitoring and evaluation systems & plans

Implementation of the monitoring and evaluation systems & plans The National Environmental Policy Act (NEPA) and its requirements Basic environmental assessment techniques

COURSE CONTENTS

Project Management Overview
The concept of effective Project M&E
Setting project objectives & targets that facilitates effective M&E
Project M&E Methods and tools
Results-based M&E
Participatory M&E
Logical Framework Analysis (LFA)
Using MS Project for Monitoring Projects
Earned Value Analysis
M&E Project and People Performance
Collecting, analyzing and storing M&E Information
Communicating and Reporting M&E findings
Introduction to EIA – EIA in Project, Types and Limitations, Cross sectoral issues and terms of reference, Participation of public and non-governmental organizations in environmental decision making Environmental Laws and Regulations
EIA Components and Methods – Processes, Screening, Scoping, Setting, Analysis, Mitigation, Matrices, Networks, Checklists, Connections and combinations of processes, Cost benefit analysis, Analysis of alternatives, Software packages for EIA, Expert systems in EIA International Environmental Impact Assessment Prediction, Assessment of Impacts and Reporting – Prediction tools for EIA, Mathematical modeling for impact prediction, Assessment of impacts Land, (Air, Water, Soil, Noise, Biological, Socio-cultural environments), Cumulative impact assessment, Documentation of EIA findings, Planning, Organization of information and visual display materials, Report preparation

Environmental Management Plan-Preparation, implementation and review, Mitigation and rehabilitation plans, Policy and guidelines for planning and monitoring programmes, Post project audit, Ethical and quality aspects of environmental impact assessment

Case Studies related to the sectors of Infrastructure, Mining, Industrial, Thermal Power, River valley and Hydroelectric,Nuclear-Power.

Textbooks and reference books

Same of Project Management for Project Monitoring and Evaluation. For EIA several national publications, acts and regulations, and the following reference books.

1. Lawrence, D.P., (2003). Environmental Impact Assessment – Practical solutions to Recurrent Problems, Wiley-Interscience.
2. Petts, J., (1996). Handbook of Environmental Impact Assessment, Vol. I and II, Blackwell Science, 1999.
3. Canter, L.W., Environmental Impact Assessment, McGraw-Hill,,
4. Biswas, A.K. and Agarwala, S.B.C. (1994). Environmental Impact Assessment for Developing Countries, Butterworth Heinemann.
5. The World Bank Group (1991). Environmental Assessment Source Book, Vol. I, II and III, The World Bank.