TRIBHUVAN UNIVERSITY
INSTITUTE OF SCIENCE AND TECHNOLOGY

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

2073 BS (2016 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 of practical per week.

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)
EGE 511	Petrology and Sedimentology	2	50
EGE 512	Structural Geology and Applied Geomorphology	2	50
EGE 513	Geology of the Himalaya	2	50
EGE 514	Solid Mechanics	3	75
EGE 515	Fundamentals of Engineering Drawings	2	50
EGE 516	Applied Mathematics and Statistics	3	75
EGE 517	*Practical I:* Petrology and Sedimentology	1	25
EGE 518	*Practical II*: Fundamentals of Engineering Drawings	1	25
EGE 519	*Practical III*: Structural Geology	1	25
EGE 520	Field work (9 days)	1	25
	Total:- 14 Theory + 3 Practical + 1 Field work	**18**	**450**

SEMESTER II

COURSE CODE	COURSE TITLE	CREDITS	MARKS (1 Cr. 25 MARKS)
EGE 551	Soil Mechanics	3	75
EGE 552	Rock Mechanics	3	75
EGE 553	Applied Geophysics	2	50
EGE 554	Engineering Hydrology and Hydrogeology	2	50
EGE 555	Site investigation and Foundation Engineering	2	50
EGE 556	Exploration Drilling and Blasting	2	50
EGE 557	Practical I: Rock Mechanics	1	25
EGE 558	*Practical II:* Soil Mechanics	1	25
EGE 559	*Practical III*: Applied Geophysics	1	25
EGE 560	*Practical IV:* Engineering Hydrology and Hydrogeology	1	25
EGE 561	Field Works (15 days)	2	50
	Total:- 16 Theory + 4 Practical + 2 Field work	**20**	**500**

SEMESTER III

COURSE CODE	COURSE TITLE	CREDITS	MARKS (1 Cr. 25 MARKS)
EGE 611	Slope Stability Analysis	2	50
EGE 612	Landslide Engineering	2	50
EGE 613	Tunnelling and Underground Excavation	2	50
EGE 614	Construction Material Engineering	2	50
EGE 615	Remote Sensing and GIS	2	50
EGE 616	Hydropower Engineering	2	50
EGE 617	Numerical Modelling and Computer Applications	2	50
EGE 618	*Practical I*: Numerical Modelling and Computer Applications	1	25
EGE 619	*Practical II:* Construction Material Engineering	1	25
EGE 620	*Practical III:* Remote Sensing and GIS	1	25
EGE 621	*Practical IV:* Landslide and Slope Stability	1	25
EGE 622	Field works (15 days)	2	50
	Total:- 14 Theory + 4 Practical + 2 Field work	**20**	**500**

SEMESTER IV

COURSE CODE	COURSE TITLE	CREDITS	MARKS (1 Cr. 25 MARKS)
EGE 651	Geotechnical Earthquake Engineering	2	50
EGE 652	Project Management	2	50
EGE 653	*Practical* I: Geotechnical Earthquake Engineering	1	25
EGE 654	Seminar	1	25
EGE 655	Dissertation	4	100
	Elective (Any One)		
EGE 661	Climate Change and Disaster Risk Management	2	50
EGE 662	Landfill Engineering and Solid Waste Management		50
EGE 663	Engineering Project Monitoring and Environmental Impact Assessment		50
	Total:- 4 Theory + 1 Seminar + 1 Practical + 4 Thesis	**10**	**350**

Full Credit: 70 and Full Mark: 1750

SEMESTER I

SEMESTER: I

EGE 511

Course Title: Petrology and Sedimentology — Full Marks: 50
Course No.: EGE 511 — Pass Marks: 25
Nature of the course: Theory
Credit 2 (30 hrs)

COURSE DESCRIPTION

This course aimed to introduce the concepts of igneous, metamorphic and sedimentary petrology and sedimentology. In petrology, it deals with the igneous, metamorphic and sedimentary rocks focusing on their origin, classification, and petrographic description. Sedimentology provides knowledge on sediment properties, sediment formation and erosion, sediment transport, and sedimentation and sediment characteristics.

OBJECTIVES

General Objective. To provide in-depth understanding of igneous, metamorphic and sedimentary rocks and their processes of formation and origin.

Specific Objective. To provide the students with knowledge and practical skills of

- Identifying composition, texture and structures of igneous, metamorphic and sedimentary rocks and classifying and describing them using modern methods of analysis,
- Recognizing, describing and classifying sediments, their properties and sedimentation processes.

COURSE CONTENTS

Part A: PETROLOGY (1 credit)

Igneous Petrology

Petrography and composition of magmatic rocks: Optical properties of rock-forming minerals in recognizing various minerals under the polarizing microscope. 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 with emphasis to identification in the field. **2 hours**

Texture and structure of igneous rocks. Crystallinity, grain size, grain shape, texture of glassy or fine-grained rocks, flow textures, intergrowth textures, reaction texture, structures in volcanic rocks, structures in plutonic rocks and structures resulting from inclusions. **2 hours**

Metamorphic Petrology

Concept of metamorphism: Definition and factors of metamorphism, types of metamorphism. **1 hour**

Nature of metamorphism: Metamorphic record of original rock, types of metamorphic processes, metamorphic field relations, imposed fabric resulting from metamorphism, mineralogical composition, isograds and grades of metamorphism, metamorphic rocks of different grades, petrography of some metamorphic rocks of the Himalayas, metamorphic zones and facies. **3 hours**

Metamorphic textures and deformations: The textures of metamorphic rocks, Relationships between metamorphism and deformation. Petrofabric study. S-C fabrics in Interpretation of deformation history. **1 hour**

Sedimentary petrology

Mineralogical composition, classification, textures, structures, origin and diagenesis of sedimentary rocks: conglomerate, sandstone, mudrocks, limestone, and dolostone. **4 hours**

Sedimentary structures: Depositional structures, erosional structures, syn-sedimentary deformational structures and their significance in engineering geology. **1 hour**

Part B: SEDIMENTOLOGY (1 credit)

Types of sedimentary particles: Solid Breakdown products of older deposits: Inorganic terrigenous sediments and carbonaceous organic debris. Particles that are not solid breakdown products of older deposits: pyroclastic particles and authigenic particles. **1 hour**

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

Physical Properties of Sediments and water sediment mixture: Mass density and Specific weight of solid particles, Submerged specific weight of a particle, Specific Gravity; Grain size, grain size classification, fall diameter, nominal diameter, gradation coefficients, probability plots and various graphic measures of size distribution; shape factor, form, sphericity and roundness; sorting, packing, orientation of particles, porosity, void ratio, dry specific weight of mixture, dry specific mass of mixture, Sediment suspension: volumetric sediment concentration, specific weight of mixture, dynamic viscosity of Newtonian mixture, kinematic viscosity of Newtonian mixture. **2 hours**

Sediment formation and erosion: Physical and chemical weathering, Concept of Erosivity and erodibility: Mechanism of erosion by fluid. Soil erosion: surface erosion: interrill and rill erosion; channel erosion: gully erosion and river erosion; Gravitational erosion: Gravity Displacement Processes: Gravity shearing, debris avalanche, debris slide, debris flow, fluidized flow, grain flow, and turbidity flow. Quantifying gully erosion and river erosion, Sediment Delivery Ratio, sediment rating curves, Annandale's Erodibility Index Method.
2 hours

Sediment transport: *Stream morpho-hydrologic parameters and Flow Velocity-Discharge Measurement***:** Stream planform parameters: Sinuosity, radius of curvature, meander length and width; Morpho-hydrologic parameters: width, cross-section, depth, maximum depth, flood prone width; Vertical Velocity Distribution, Velocity Profile Measurement, discharge measurement: Area-velocity method. **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, and Darcy-Weisbach Equation. Hydraulic flow-resistance factors. Estimating Total Roughness using Cowan's Method. **1 hour**

Sediment loads: Modes of transport, Bedload transport, Incipient motion, Boundary conditions. Bed Shear or Tractive Force, Empirical equation, Shields Diagram, Hjulström Approach. Suspended load Transport: Sediment Concentration Profile, Total Sediment Load and Transport Capacity. **2 hours**

Sediment Deposition and sediment characteristics: *Lake or reservoir*: Settling velocity of mud and coarse grains, simplified equations for fall velocity. Flocculation. Subaqueous gravity displacement sedimentation: 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*: glacial and periglacial deposits. **4 hours**

TEXTBOOKS

1. Best M. G. (1986): *Igneous and Metamorphic Petrology,* CBS Delhi, 639p.
2. Yardley B. W. D. (1990): *An Introduction to Metamorphic Petrology, ELBS, 248p.*
3. Tucker, M.E. (1981). *Sedimentary petrology: an Introduction. Geoscience Texts Vol.3. Blackwell Scientific publications.252p*
4. Tamrakar, N.K. (2011): *Practical Sedimentology. Bhrikuti Academic Publication, Kathmandu, 232p.*
5. Morris, G. L. and Fan, J., (2010), *Reservoir Sedimentation Handbook, McGraw-Hill, 805p.*

6. Friedman, G.M. and Sanders, J.E. (1978): *Principles of Sedimentology. . John Wiley and Sons, New York, 792p*.
7. Collinson, J.D. And Thompson, D.M. (1994): *Sedimentary structures, CBS, Delhi, 207p.*
8. Pettihohn, F.J. (1975). Sedimentary rocks. *Harper and Row, New Yo5rk, 628p.*
9. Richard C. Selley, (2000), *Applied Sedimentology, Second Edition, Academic Press, 543p.*

REFERENCE BOOKS

1. Phillpots, A. R. (1994): *Principles of Igneous and Metamorphic Petrology,* Prentice-Hall of India Pvt. Ltd., 498 p.
2. Phillpots, A. R. (2003): *Petrography of Igneous and Metamorphic Rocks,* Waveland Press, Inc., 178 p.
3. Paudel, L. P. (2011). *Study of Minerals and Rocks in Thin Sections*. GEOS, 102p.
4. Rai, S. M. (2011): *Study of Minerals and Rocks in Hand specimens*. Creative Work, Nepal, 152p.
5. Thorpe, R. S. and Brown, G. C. (1995): *The Field Description of Igneous Rocks,* John Weiley & Sons, 154 p.
6. Hutchinson (1974): *Laboratory Methods in Petrography,* John Wiley and Sons, New York, 527 p.
7. Winkler H. G. F. (1987): *Petrogenesis of Metamorphic Rocks.* 5th edition, Narosa Publishing House Delhi, 348 p.
8. Roy Lindholm, (1999), A practical approach to sedimentology. CBS Publishers & Distributors, Delhi, 176p.
9. Greensmith, J.T. (1978). Petrology of the sedimentary rocks. (sixth Edition). George Allen & UNWIN/Thomos Murby, London, boston, Sydney.

SEMESTER: I *EGE 512*

Course Title: Structural Geology and Applied Geomorphology Full Marks: 50
Course No.: EGE 512 Pass Marks: 25
Nature of the course: Theory
Credit 2 (30 hours)

PARTA: STRUCTURAL GEOLOGY

COURSE DESCRIPTION

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

OBJECTIVES

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

Specific Objective. It aims to provide students with the basic concepts of deformation of rocks, and of the mechanisms and causes of deformation. Students will get in-depth knowledge and practical skills for the study, analysis, and interpretation of folds, faults, joints, foliation, and lineation, and the concepts of stress and strain. It will familiarize students how to describe and record geological structures in the field; and enable students how to evaluate, analyze and interpret structural data.

COURSE CONTENTS

Introduction. Concept, approach, and scope of structural geology. Primary and secondary structures. Primary sedimentary structures and their significance in structural geology. Structure of igneous rocks.
1 hour

Introduction to stereographic projections. Concept of stereographic projection, plotting a line and a plane, determination of the rake of a line, true dip and apparent dip problems, determining the Intersection of two planes. Determination of an intersection lineation, bisecting the angle between two planes. Rotation of a line and a plane about a vertical and a horizontal axis. Graphical treatment of the fabric data. Plotting and analysis of various structural elements. Uses and limitation of pi and beta diagrams. **1 hour**

Kinematic analysis. *Deformation,* definition, components of deformation, homogeneous and inhomogeneous deformation. **1 hour**

Strain. *Definitions.* Displacement vectors, Homogeneous and inhomogeneous deformations. One dimensional strain, strain in two dimensions, three dimensional strain, calculation of finite strain in two dimensions, strain ellipse and strain ellipsoid, angular shear and shear strain, Finite strain ellipse, strain equations, the finite strain ellipsoid and plain strain, coaxial and non-coaxial strain, Lagrangian and Eulerian specifications. Homogeneous deformation of straight line. Circle and ellipse (theory), progressive deformation, types of homogeneous strain ellipsoids and effect of volume change on deformation. Determination of finite strains from originally spherical and ellipsoidal markers. Behaviour of rocks with respect to stress and strain.
2 hours

Stress. *Definition.* Magnitude and units, Stress on a point. Stress on a plane. Normal stress and shear stress, stress components, stress tensor, Stress ellipse and stress ellipsoid, principal planes of stress and axial cross section, stress equations, . Mohr stress diagrams, relations between stress and strain. Rheology, elastic, plastic and viscous models of rock behaviour, stress in two and three dimensions. **2 hours**

Deformation mechanism and microstructures. Crystalline structures and strength of solids, deformation mechanism. **1 hour**

Folds*. Basic definitions*. Geometric analysis of folds, describing shape and size of folded surfaces (parameters of defining single fold surface), fold classification based on changes in layer thickness, classification based on dip isogon, kinematic analysis of folding, mechanics of buckling, Small-scale structures in folds and their interpretation, kink folding, Distribution of strain in folds, superposed folding. **1 hour**

Cleavage and foliations. Cleavage: Definitions*.* Geometric relationship of cleavage to folding and shearing, types of cleavages microscopic properties of cleavage, secondary tectonic cleavage (crenulation cleavage). Foliation**:** Definition*.* Primary and secondary foliation, metamorphic foliation, foliations in mylonitic rocks, orientation of foliation within strain ellipsoid. **1 hour**

Lineations. *Definition.* Types of lineation, types of linear structures, their relation with respect to strain ellipsoid. Significance of lineation in tectonic history, Relationship between planner and linear elements, lineations and kinematics. **1 hour**

Joints*: Definition*. Joints and shear fractures, characteristics of individual joint surfaces, propagation of individual fracture surfaces, classification and significance. **1 hour**

Faults. Fault terminology, physical characters of faults, fault rocks, naming of faults, displacement, slip and separation, classification based on slip and separation, thrusts, Normal, and strike slip faults, their classification and characters. Mechanism of faulting with reference to stress and strain ellipsoids, the birth and growth of faults. **1 hour**

Shear zones and mylonites. *Definition*. Classification and geometry of different types of shear zones. Brittle and plastic (ductile) shear zones, mylonites and kinematic indicators, Strain variations within shear zone. **1 hour**

Principles of Tectonics. Orogeny and epeirogeny. Thrusts and nappes. Schuppen and duplex. Geosynclines and continental margins. Continental drift. Introduction to plate tectonics. Sea floor spreading. Mid-oceanic ridges. Palaeomagnetism. Seismic zones. Transform faults and triple junctions. Island arcs. Causes of orogeny and global tectonics. Orogenic belts with special references to the Himalaya. **1 hour**

PART B: APPLIED GEOMORPHOLOGY

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

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

COURSE CONTENTS

Approach and Morphological evolutionary system: Fundamental concept of geomorphology, geomorphological system: outline of geomorphic process, geomorphic scale. The cycle of erosion, interruptions of the cycle of erosion, denudation chronology, criticisms of the cycle and alternative models, strategies for inferring landform evolution, new evolutionary concepts. **2 hours**

Igneous activity and landforms: Igneous activity in space and time, intrusive and extrusive constructional landforms, igneous activity in tectonic region. **1 hour**

Tectonic and Structural landforms: Horizontal and domed structures: types of domal structure, topographic expression, Homoclinal structures, folded, faulted: horst, grabens and related form, thrust control landform, diastrophism, diastrophism and erosion. **1 hour**

Weathering and soil: Geomorphic Significance of weathering, Formation of soil: description of major soil group, soil profile, landform evolution. Karst terrain: Surface landforms of karst, underground features of karst, types of karst terrain. **1 hour**

Mountain Environment and hillslopes: Evolution and classification of hill slopes, origin of hill slopes, hill slope erosion. Large scale landslides, flash flood, landslide dam and GLOF resulting landforms. **2 hours**

Fluvial process and landform: Braided and meandering system, sediments transport, hydrology, river morphology, rivers and valley morphology, Fluvial depositional landforms: Alluvial fans, valley fill, deltas. **1 hour**

Drainage basins: The basin geomorphic unit, morphometric analysis, morphometric control, drainage basin evolution, drainage basin response. **1 hour**

Aeolian processes and landforms: Aeolian environments, aeolian sand movement, wind abrasion, aeolian bedforms, cold and hot desert, coastal sand dunes, loess, snow drifting. **1 hour**

Glacier process and landform: Types of glaciers, glacier ice, glacier motion (flow), rock debris in glaciers, processes affecting debris at the glacier sole, erosion by glaciers, deposition by glaciers, landforms of glacial deposition, glacier melt water subsystem. Geomorphological effects of former glacier expansion. **1 hour**

Application of geomorphology: Application of geomorphology in hydrology, hydrogeology, engineering projects and in the urbanization. **1 hour**

Climatic geomorphology: Climate influence upon geomorphic process, humid tropical landforms, tropical wet-dry landforms, arid and semi-arid landforms, cold region landforms, the geomorphic effects of climatic change **1 hour**

Paleogeomorphology: Introduction, relict, buried, exhumed land form **1 hour**

Geoinformatics in Geomorphology: Remote Sensing and GIS in Tectonic geomorphic studies, Groundwater evaluation and delineating fractured aquifer zone in hilly terrain. **1 hour**

TEXTBOOKS

1. Richard John Huggett, 2007. Fundamentals of geomorphology, Second Edition. ISBN 0-203-94711-8
2. Burbank, D. W. and Anderson, R. S. (2007). Tectonic Geomorphology, *Blackwell Science.*
3. Fossen, H, (2010). Structural Geology. *Cambridge University Press. 463p.*
4. Davis G.H. and Reynolds, S.J. (1996). Structural Geology, Rocks and Regions (Second Edition). *John Wiley and Sons, INC.776 p.*
5. Hobbs, B. E., Means, W. D., and Williams, P. F. (1976). An Outline of Structural Geology. *John Wiley and Sons, 571 p.*

REFERENCE BOOKS

1. McClay, K. R. (1987). The Mapping of Geological Structures*, John Wiley and Sons Inc., 161 p.*
2. Ragan, D. M. (1985). Structural Geology, An Introduction to Geometrical Techniques, 3rd edition, *John Wiley and Sons Inc., 393 p.*
3. Chorley, R., Schumm, S.A., and Sugden, D.E. (1984). Geomorphology, *Methuen, 605p.*

4. Thornbury, D. W. (2000). Principles of Geomorphology, *New age International (P) Limited, Publishers, India. 594 p*
5. Marshak and Mitra. Basic methods of structural geology
6. Suppe J. (1985). Principles of Structural Geology. Prentice-Hall, Englewood Cliffs, New Jersey, 537p.
7. P. G. Fookes, E. M. Lee and G. Milligan. Geomorphology for Engineers. Whittles Publishing, CRC Press-Taylor & Francis Group. ISBN 978-1870325-03-5
8. Douglas W. Burbank and Robert S. Anderson. Tectonic Geomorphology. Blackwell Science. ISBN 978-0-632-04386-6
9. Siddan Anbazhagan, S. K. Subramanian and Xiaojun Yang. Geoinformatics in Applied Geomorphology. CRC Press- Taylor & Francis Group, 2011. ISBN 13: 978-1-4398-3049-9 (eBook)

SEMESTER: I *EGE 513*

Course Title: Geology of the Himalaya Full Marks: 50
Course No.: EGE 513 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 hours**

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. Valdiya (2010). Making Of India - Geodynamic Evolution. *MacMillan, India*
2. 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*
3. Valdiya, K. S. (1998). Dynamic Himalaya*, Universities Press, New Delhi.*
4. Valdiya, K. S. (1994). Aspects of Tectonic focus on South Central Asia, *Tata McGrawHill.*
5. 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 Earthsciences 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 *EGE 514*

Course Title: Solid Mechanics Full Marks: 75
Course No.: EGE 514 Pass Marks: 37.5
Nature of the Course: Theory
Credit: 3 (45 hrs)

COURSE DESCRIPTION

The students will learn about Partial differential equations and integral equation, Fourier integral, theory of stress and strain. Theory of elasticity and viscosity.

OBJECTIVES

General Objectives. Learn the principles of deformation mechanism and mechanical properties materials.

Specific Objectives. The students will be have the basic knowledge of Stress and strain, principles of mechanics, deformation mechanism, energy and work, elasticity and viscosity of materials.

COURSE CONTENTS

Statics of Rigid Bodies: Statics of Rigid Bodies – Mechanics, Rigid and Deformable bodies, Equations of Static and Dynamic Equilibrium, Free-Body Diagrams. The Continuum – Classical definition and Material Continuum, The Concept of Stress in the Definition of Material Continuum. Vectors and Tensors, Vector Equations, Indicial Notation, Summation Convention and Differentiation, Matrices and Determinants, Partial differential Equations and Integral Equations, Fourier Integral, Functional Approximations. **4 hours**

Stress and Strain: Stresses: General Concept of Stress, Surface and Contact Stress, Internal Stress, Body Forces, Method of Sections, Normal and Shear Stresses, General State of Stress at a Point, Stress Tensor, Partial Differential Equations of Equilibrium, Stresses Acting on Arbitrary Planes, Transformation of Stress, Principal Stresses and Directions, Stress Invariants, Plane Stress, Octahedral Stress, Mean and Deviator Stresses.
Strains: Definition of Strain, displacement Field, Strain Displacement Relations, Strain Components, Strain Compatibility, Transformation Equations for Strain in Three Dimensions, Plane Strain, Properties of Strain.
8 hours

Linear Elasticity: Hooke's Law, Stress-Strain Relationship for Mild-Steel; Linear Elastic, Non-linear Elastic and Inelastic or Plastic Material; Elastic Constants and their Relations; Isotropic and Anisotropic Materials; Generalized Hooke's Law; Constitutive Relations for General Anisotropic and Isotropic Materials in Three Dimensions; Plane Stress and Plane Strain Problems; Axisymmetric Solids with Constitutive Relations. Torsion and Torsion formula; Thin-Walled Pressure vessel Theory; Simple beam Theory – Flexure Formula and Deflection of Simple Beams; Elastic Buckling; Euler's Formula for Buckling of Columns. **10 hours**

Failure Criteria: Failure of Elastic Material; Concept of Yield Criteria and Yield Surface for Isotropic Ductile materials, Maximum Normal Stress Theory for Brittle Fracture; Comparison of the Theories. **4 hours**

Energy and Virtual Work: Energy in Deforming Materials, Elastic Strain Energy and Complementary Energy, Strain Energy Potentials, Virtual Work Principle, The Principle of Minimum Potential Energy. **6 hours**

Viscoelasticity: The Response of Viscoelastic Materials, Models of Linear Viscoelastic Bodies, Examples and Applications of Viscoelastic Materials, Rheological Models, The Hereditary Integral, Linear Viscoelasticity and the Laplace Transform, Oscillatory Stress, Dynamic Loading and Vibrations, Temperature Dependent Viscoelastic Materials. **8 hours**

Plastic Limit Analysis: Introduction, Plastic limit analysis of Beams, Continous Beams and frames. **5 hours**

TEXT BOOK

Irving H. Shames, James M. Pitarresi (1999), Introduction to Solid Mechanics (3rd Edition).

REFERENCE BOOK

Edor P Popov and Toader A Balan, Engineering Mechanics of Solids (Second Edition).

Y. C. Fung (1994), A First Course in Continuum Mechanics (3rd edition).

SEMESTER: I *EGE 515*

Course Title: Fundamentals of Engineering Drawings Full Marks: 50
Course No.: EGE 515 Pass Marks: 25
Nature of the Course: Theory
Credit: 2 (30 hrs)

COURSE DESCRIPTION

The students will learn the Instrumental and free hand drawing techniques, applied geometry, theory of projection drawings, multiview and sectional view drawings.

OBJECTIVES

General Objectives. The students will have the knowledge and skill and knowledge on basic engineering drawings.

Specific Objectives. The main objectives of this course is to provide the students the skills of instrument and free hand lettering and drawing, learn the multiview and sectional drawing and develop the capacity to understand various types of civil engineering drawings and designs.

COURSE CONTENTS

Engineering Drawings, Equipment, and Materials: Fundamental concept on necessity of engineering drawing and equipment details: Uniformity in Engineering drawing, instrument used to prepare engineering drawing and their uses, drawing sheets preparation, use of standards and commonly accepted practices in engineering drawing. **1 hour**

Freehand Technical Lettering: Difference between freehand and technical lettering, uses of technical lettering, essential features of technical lettering such as legibility, uniformity, ease, rapidity, and suitability. Concept of lettering strokes, letter proportions, use of pencils and pens, uniformity and appearance of letters, inclined and vertical letters and numerals, upper and lower cases, standard English lettering forms**.** **1 hour**

Dimensioning: Importance of dimensioning in Engineering drawing, elements of dimensioning, aligned and unidirectional system, standard rules to follow during dimensioning. **2 hours**

Applied Geometry: Concept of plane and solid geometric construction, Bisecting and trisecting lines and angles, proportional division of lines, construction of angles, triangles, squares, polygons. Constructions using tangents and circular arcs. Methods drawing standard curves such as ellipses, parabolas, hyperbolas, involutes, spirals, cycloids and helices, solid regular objects such as: Prisms: Square, cubical, triangular and oblique, Cylinders: right and oblique, Cones: right and oblique**.** **4 hours**

Basic Descriptive Geometry: Application of descriptive geometry principles to the solution of problems involving positioning of objects in three-dimensional space. The Projection of points, lines and planes in space**.**

3 hours

Theory of Projection Drawing: Develop concept on projection, line of site, plane of projection, Fundamentals of Perspective projection drawing, orthographic projection, axonometric projection, oblique projection, first and third angle projection, systems and projection. **4 hours**

Multiview Drawings: Methods for obtaining orthographic views; Projection of lines, angles and plane surfaces, analysis in three views; Projection of curved lines and surfaces; Object orientation and selection of views for best representation; Full and hidden lines. Making an orthographic drawing; Visualizing objects from the given views; Interpretation of adjacent areas; True-length lines; Representation of holes; Conventional practices

3 hours

Sectional Views: Full section view, half section, broken section, revolved section, removed (detail) sections, phantom of hidden section, auxiliary sectional views, specifying cutting planes for sections, conventions for hidden lines, holes, ribs, spokes. **3 hours**

Auxiliary Views: Basic concept and use of auxiliary views, drawing methods and types of auxiliary views, symmetrical and unilateral auxiliary views, projection of curved lines and boundaries, line of intersection between two planes, true size of dihedral angles, true size and shape of plane surfaces. **3 hours**

Freehand Sketching and Visualization: Concept of size of paper & original scale, orientation of the object, minimum detail to communicate the idea, view of sketch, Techniques of sketching: Pencil hardness, squared paper, line densities, Techniques for horizontal, vertical and circular lines. **2 hours**

Developments and Intersections: General concepts and practical considerations for development of surfaces, Parallel line development, Radial line development, Triangulation development, Approximate development. **2 hours**

Topographical Drawings: Concept on developing topographical maps using the survey data, use of software such as AutoCad to develop the maps**.** **2 hours**

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

SEMESTER: I *EGE 516*

Course Title: Applied Mathematics and Statistics Full Marks: 75
Course No.: EGE 516 Pass Marks: 37.5
Nature of the Course: Theory
Credit: 3 (45 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

Review. Limit, continuity, derivability of functions of a single variable, derivative rules and formulas, integration rules and standard integrals. **1 hour**

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. **4 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. **3 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. **3 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. **3 hours**

Trigonometry. Introduction, Trigonometric functions, Determining unknown angles and distances, Cartesian coordinates and trigonometric functions of angles, Trigonometry in a three-dimension, Introduction to vectors, Exercises: From Text Book (Mathematics. A Simple Tool for Geologists) 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9,5.10, 5.16. **1 hour**

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. **3 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.

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 F-Distribution, F-test of equality of variances, Analysis of variance, Fixed, random, and mixed effects, Two-way analysis of variance, Nested design in analysis of variance, The Chi square Distribution, Goodness-of-fit test , 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.

4 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

3 hours

TEXT BOOKS

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.*

SEMESTER: I *EGE 517*

Course Title: Practical I: Petrology and Sedimentology Full Marks: 25
Course No.: EGE 517 Pass Marks: 12.5
Nature of the course: Practical
Credit: 1 (45 hrs)

COURSE DESCRIPTION

The students will study igneous, sedimentary and metamorphic rocks in hand specimen and thin-section. In sedimentology, they will study sediments.

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

Petrology and Sedimentology Practicals

Lab 1: Study of optical properties of some rock forming minerals under the polarizing microscope

Lab 2: Study of igneous and metamorphic rocks in hand specimens and under the polarizing microscope

Lab 3: Study of siliciclastic rocks in hand specimens and under polarizing microscope

Lab 4: Study of carbonate rocks in hand specimens and under polarizing microscope

Lab 5: Grain size analysis of unconsolidated gravelly and sandy sediments using sieve methods.

Lab 6: Grain size analysis of unconsolidated silts and clay sediments using pipette method.

Lab 7: Analysis of sphericity, roundness and surface features of unconsolidated sands under binocular microscope

Lab 8: Analysis of particle composition, form, sphericity, roundness, and surface features of unconsolidated gravelly sediments

Lab 9: Construction of velocity distribution in stream channel and discharge calculation using Area-Velocity Method.

Lab 10: 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.

SEMESTER: I *EGE 518*

Course Title: Practical II: Engineering Drawings Full Marks: 25
Course No.: EGE 518 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 - **3 hours**
2. Applied Geometry (Sketch and Instrumental Drawing) - **3 hours**
3. Descriptive Geometry : Projection of Point, Lines and planes - **6 hours**
4. Multiview Drawings, Sectional Drawings and Dimensioning - **6 hours**
5. Projection of Regular Geometrical Solids (Sketch and Instrumental Drawing) - **3 hours**
6. Familiarization with Graphical Symbols (Symbols for Different Engineering Fields) - **3 hours**
7. Detail Drawing - **6 hours**
8. Assembly Drawing - **3 hours**
9. Building Drawing - **6 hours**
10. 3d sketch using Autocad - **6 hours**

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

SEMESTER: I *EGE 519*

Course Title:	Practical III: Structural Geology	Full Marks: 25
Course No.:	EGE 519	Pass Marks: 12. 5

Nature of the Course: Practical
Credit: 1 (45 hrs)

COURSE DESCRIPTION

The students will learn to interpret structural features and stratigraphy from the geological maps, and lean the techniques of stereographic projections to handle structural data.

OBJECTIVES

General Objectives. To provide students with the knowledge and skills about interpretation of geological maps and cross-section, and use of stereographic projections in structural geology.

Specific Objectives:

- Use of topographic maps to make crossections, prepare, interpretations and preparation of crossections from given geological maps.
- Plotting geologic data on stereonets and their interpretations. Orthographic projection of structural data and problem solving and borehole data analysis.

COURSE CONTENTS

STRUCTURAL GEOLOGY PRACTICAL

Lab 1: Contours and topography. Relationship between contours and geologic contacts. Rule of V's.

3 hours

Lab 2: Study of structural features and stratigraphic sequence of the given geological maps. **3 hours**

Lab 3 -8: Study of geological maps and preparation of geological cross-sections of horizontal, inclined, vertical, and folded beds. Study of geological maps with unconformity, faults, and dykes. Apparent and true thickness of beds. Determination of throw of faults. **18 hours**

Lab 9-11: Stereographic projection techniques. Plotting a line and a plane on the stereo net. Pole to the plane. Pole net and its use. Trend, plunge, and pitch of a line and their representation on the stereo net. Dip and strike of a plane and their representation on the stereo net. Apparent dip and true dip. Line of intersection of two planes. Pi and beta diagrams. Rotation of structural data by using the stereo net. Contouring techniques. **9 hours**

Lab 12-13: Three - point - problems. Borehole data analysis and interpretation. Depth and distance calculations. True and apparent dips. Calculation of vertical and horizontal throw. **6 hours**

Lab 14-15: Fault Problem: Geometrical and stereographic techniques for the determination of net slip, dip slip, and strike slip along the fault planes. **6 hours**

STRUCTURAL GEOLOGY 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. McClay, K. R. (1987). The Mapping of Geological Structures, *John Wiley and Sons Inc., 161 p.*
3. Ragan, D. M. *(1985).* Structural Geology, An Introduction to Geometrical Techniques, 3rd edition, *John Wiley and Sons Inc., 393 p.*
4. Chorley, R. 3, Schumm, S.A., and Sugden, D.E. (1984). Geomorphology, *Methuen, 605p.*
5. Thornbury, D. W. (2000). Principles of Geomorphology, *New age International (P) Limited, Publishers, India. 594 p*

SEMESTER: I

EGE 520

Course Title: Field works — Full Marks: 25

Course No.: EGE 520 — Pass Marks: 12.5

Nature of the course: Field

Credit: 1 (9 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 9 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 scale, and also prepare a detailed columnar section.

The fieldwork will be carried out in Lesser Himalayan 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 of Field	Descriptions	Credit 1: (56 field 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	Route Mapping (1:5000 scale)	7 hours
Day 5	Route Mapping (1:5000 scale)	7 hours
Day 6	Geological Mapping of a given area (1:25000 scale)	7 hours
Day 7	Geological Mapping of a given area (1:25000 scale)	7 hours
Day 8	Geological Field Report writing	4 hours
Day 9	Field Viva and Return back from the fieldwork area	3 hours
	TOTAL	= 56 hours

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 *EGE 551*

Course Title: Soil Mechanics Full Marks: 75
Course No.: EGE 551 Pass Marks: 37.5
Nature of the Course: Theory
Credit: 3 (45 hrs)

COURSE DESCRIPTION

This course covers the introductory part of soil mechanics.

OBJECTIVES

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

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, plasticity, and classification. Introduction, soil size limits, clay, nature of water in clay, repulsive potential, repulsive pressure, flocculation and dispersion of clay particles, consistency of cohesive soils, liquidity index, activity, grain-size distribution of soil, weight–volume relationships, relative density and relative compaction, effect of roundness and non-plastic fines, unified soil classification system.

4 hours

Stresses and strains. Introduction, Basic definition and sign conventions for stresses, Equations of static equilibrium, Concept of strain, Hooke's law, plane strain problems; equations of compatibility for three-dimensional problems, stresses on an inclined plane and principal stresses for plane strain problems, strains on an inclined plane and principal strain for plane strain problems, stress components on an inclined plane, principal stress, and octahedral stresses three-dimensional case , strain components on an inclined plane, principal strain three-dimensional case.

5 hours

Stresses and displacements in a soil mass. Introduction, vertical line load on the surface vertical line load on the surface of a finite layer, vertical line load inside a semi-infinite mass, horizontal line load on the surface, horizontal line load inside a semi-infinite mass, uniform vertical loading on an infinite strip on the surface, uniform strip load inside a semi-infinite mass, uniform horizontal loading on an infinite strip on the surface, triangular normal loading on an infinite strip on the surface, vertical stress in a semi-infinite mass due to embankment loading.

5 hours

Pore water pressure due to undrained loading. Introduction, pore water pressure developed due to isotropic stress application, pore water pressure parameter, pore water pressure due to uniaxial loading, directional variation, pore water pressure under triaxial test conditions, Henkel's modification of pore water pressure equation, pore water pressure due to one-dimensional strain loading.

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, Electro-osmosis, Seepage equation of continuity; Use of continuity equation for solution of simple flow problem, flow nets, Hydraulic uplift force under a structure, Flow nets in anisotropic material, Construction of flow nets for hydraulic structures on non-homogeneous subsoils, numerical analysis of seepage, seepage force per unit volume of soil mass, safety of hydraulic structures against piping, filter design, calculation of seepage through an earth dam resting on an impervious base, plotting of phreatic line for seepage through earth dams, entrance, discharge, and transfer conditions of line of seepage, through earth dams and flow net, construction for earth dams.

10 hours

Consolidation Introduction, theory of one-dimensional consolidation, degree of consolidation under time-dependent loading, numerical solution for one-dimensional consolidation, standard one-dimensional consolidation test and interpretation, effect of sample disturbance, secondary consolidation, general comments on consolidation tests, calculation of one-dimensional consolidation settlement, coefficient of consolidation, one-dimensional consolidation with visco-elastic models, constant rate-of-strain consolidation tests, constant-gradient consolidation test, sand drains, numerical solution for radial drainage (sand drain) general comments on sand drain problems.

5 hours

Shear strength of soils. Introduction, Mohr–Coulomb failure criteria, shearing strength of granular soils, critical void ratio, curvature of the failure envelope, general comments on the friction angle of granular soils, shear strength of granular soils under plane strain condition, shear strength of cohesive soils, unconfined compression test, modulus of elasticity and Poisson's ratio from triaxial tests, friction angles, effect of rate of strain on the undrained shear strength, effect of temperature on the undrained shear strength, stress path, Hvorslev's parameters, relations between moisture content, effective stress, and strength for clay soils, correlations for effective stress friction angle, anisotropy in undrained shear strength, sensitivity and thixotropic characteristics of clays, Vane shear test, relation of undrained shear strength and effective overburden pressure, creep in soils.

10 hours

Settlement of shallow foundations. Introduction, elastic settlement, modulus of elasticity and Poisson's ratio, settlement based on theory of elasticity, generalized average elastic settlement equation, improved equation for elastic settlement, calculation of elastic settlement in granular soil using simplified, strain influence factor, consolidation settlement, One-dimensional primary consolidation settlement calculation, Skempton–Bjerrum modification for calculation of consolidation settlement, settlement of over-consolidated clays, settlement calculation using stress path, comparison of primary consolidation settlement calculation, secondary consolidation settlement, pre-compression for improving foundation soils.

7 hours

TEXT BOOK

1. Braja M. Das (2009) Advanced Soil Mechanics, Third edition, Taylor and Francis: New York, London. 592 p.
2. Lambe T. W. and Whiteman R. V. (2000). Soil Mechanics, SI Version, *John Wiley & Sons.*
3. Reddy, R. N. (2010). (ed.): Soil Engineering Testing, Design and Remediation. Gene-Tek Books, New Delhi.

REFERENCE BOOK

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 *EGE 552*

Course Title: Rock Mechanics Full Marks: 75
Course No.: EGE 552 Pass Marks: 37.5
Nature of the Course: Theory
Credit: 3 (45 hrs)

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.

COURSE CONTENT

Introduction. Fields of application of rock mechanics, the nature of rocks, sources of information in rock mechanics

1 hour

Classifications and index properties of rocks. Geological classification of rocks, engineering significance of igneous, sedimentary and metamorphic rocks, index properties of rock systems, porosity, density, permeability, strength, slaking and durability, sonic velocity as and index to degree of fissuring, other physical properties, classification of rock masses for engineering purposes: Q-system, RMR, MRMR and other rock mass classification schemes, limitations of rock mass classifications.

5 hours

Rock strength and failure criteria. Modes of failure of rock, common laboratory strength tests, stress-strain behavior in compression, the meaning of rock strength, application of the complete stress-strain curve, the Mohr Coulomb failure criterion, the effect of water, the influence of the principle stress ratio on failure, empirical criteria of failure, the effect of size on strength, anisotropic rocks, use of rock mass classifications for rock strength prediction

5 hours

Initial stresses in rocks and their measurement. Influence of the initial stresses, estimating the initial stresses, techniques for measurement of in-situ stresses

3 hours

Planes of weakness in rocks. Introduction, joint orientations, joint testing, joint roughness, interrelationship among displacements and strengths, effect of water pressure

3 hours

Graphical representation of discontinuity data. Equal area and equal angle projections, stereographic projection of a plane and its pole, determination of the line of intersection of two planes, plotting and analysis of field measurements, processing of structural data in computer

4 hours

Deformability of rocks. Introduction, elastic constants, measurement of deformability properties by static tests, dynamic measurements, fractured rocks, the influence of time on rock deformation

3 hours

Application of rock mechanics to rock slope engineering. Introduction, modes of failure of slopes in hard rock, kinematic analysis of slopes, analysis of plane slides, analysis of plane sliding on the stereographic projection, analysis of wedge sliding using the stereographic projection, analysis of slides composed of two blocks

4 hours

Application of rock mechanics to foundation engineering. Rock foundations, allowable bearing pressures in codes: behavior modes, stresses and deflections in rock under footings, allowable bearing pressures on footings on rocks, deep foundation in rock, subsiding and swelling rocks.

5 hours

Tunneling. Introduction, natural state of stress, stress around tunnel openings in an elastic medium, stress around tunnels in an elasto-plastic medium, stresses around tunnels in broken rock, NATM and other tunneling methods, Barton's theory, tunnel support, concrete and shotcrete lining, geological factors in tunneling, rock mass classification system, monitoring of tunnel behavior, environmental impact of tunneling and excavations.

7 hours

Dam Foundations. Introduction, engineering geological site investigation for dam construction, determination of geotechnical parameters, hydrological aspects of the foundation rock, forces in dam foundations, deformation of dam foundation without failure, failure of dam foundations.

5 hours

TEXT BOOK AND REFERENCE BOOKS

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 *EGE 553*

Course Title: Applied Geophysics Full Marks: 50
Course No.: EGE 553 Pass Marks: 25
Nature of the course: Theory
Credit 2 (30 hours)

COURSE CONTENTS

Introduction to 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

Gravity method. Basis for gravity exploration, Normal gravitational field. Determination of absolute gravity. Gravimeters: Spring mass system as basic gravimeters, principles of working of unstable gravimeters, zero length spring, LaCosteRomberg and Worden gravimeters. Densities of common rocks and minerals. Techniques of gravity surveys, gravity anomalies, qualitative and quantitative interpretation. Application of gravity methods in engineering problems.

8 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.

4 hours

Electrical methods. Electrical properties of rock and minerals, True and apparent resistivity, resistivities of common rocks and minerals. Resistivity and IP Method: Electrode configurations—Sounding (Schlumberger) and Profiling (Wenner), Interpretation of VES curves. Magnetotelluric and EM methods. Basic EM theory: amplitude and phase methods, VLF method; basic principles of magnetotelluric methods.

7 hours

Seismic Method. Principles of Geometrical Optics, generation and propagation of seismic waves, seismic energy sources, geometry of refraction and reflection, interpretation of travel time curves for two layered earth horizontal and dipping interface, field procedure profile and broad side shooting, fan shooting, end on and split spread arrangements. Wave paths and time distance relations for horizontal layers in seismic refraction. Refraction shooting across a fault. Dipping beds. Delay times.

8 hours

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

1 hour

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 *EGE 554*

Course Title: Engineering Hydrogeology and Hydrogeology

Full Marks: 50
Pass Marks: 25

Course No: EGE 554
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, annual gages, crest stage gages, miscellaneous stage gages, selection of station site. **Discharge.** Reservoir evaporation, combination methods of estimating reservoir evaporation, estimation of reservoir evaporation from pan evaporation and related meteorological data, summary and appraisal of techniques for estimating reservoir evaporation, increased water supplies through reduced evaporation.

1 hour

Evapo-Transpiration. Factors affecting transpiration, measurement of transpiration. Water budget determination of mean basin evapo-transpiration, field plot determination of evapo-transpiration, lysimeter determination of evapotranspiration, estimating potential evapo-transpiration from meteorological data, estimating actual evapo-transpiration from potential irrigation water requirements, controlling evapotranspiration, equations for evapo-transpiration computations.

1 hour

Stream Flow Hydrographs. Characteristics of hydrograph, components of runoff, stream flow recessions, hydrograph separation, analysis of complex hydrographs, and determination of total runoff. The elemental hydrograph, the unit hydrograph concept, derivation of unit hydrographs from complex storms, conversion of unit hydrograph duration, synthetic unit hydrographs, application of unit hydrographs, hydrographs of overland flow.

1 hour

Relation between Precipitation and Runoff. The phenomena of runoff, surface retention, runoff mechanisms, the runoff cycle, estimating the volume of storm runoff, initial moisture conditions, storm analysis, multivariate relations for total storm runoff, relations for incremental storm runoff, infiltration approach to runoff estimates, infiltration indexes, estimating snowmelt runoff: physics of snow melt, estimating snow melt rates and consequent runoff, seasonal and annual runoff relations, precipitation runoff relations, use of snow surveys.

2 hours

Hydrological Routing: Wave movement, waves in natural channels, the storage equation, determination of storage, treatment of local inflow, reservoir routing, routing in river channels, channel routing, graphical methods, deriving basin outflow by routing, gage relations.

2 hours

Hydraulic Routing. Governing equations, dynamic wave velocity, numerical techniques, routing with complete equations, kinematic routing, zero-inertia routing.

2 hours

Probability in Hydrology. A basis for planning flood probability, selection of the data, plotting positions, theoretical distributions of flood, Log-Pearson type III distribution, extreme value type distribution, selection of design frequency, regional flood frequency, frequency analysis from synthetic data, conditional probability, frequency events, probability of runoff volume distribution, drought, precipitation probability distribution, generalization of rainfall frequency data, adjustment of fixed interval precipitation amounts, rainfall frequency maps, design storm.

2 hours

Application of hydrology. Data preparation, record extension, water supply reservoirs, flood regulations, channel improvement for flood mitigations, flood plain mapping, urban storm drainage, highway culverts, spillway design, cooling pond design.

2 hours

HYDROGEOLOGY

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

General circulation, Temperature, Humidity and wind. Thermal circulation, effects of earths rotation, jet streams, effect of land and water distribution, migratory systems, fronts. Geographic distribution of temperature, humidity and wind. Properties of water vapour. Measurement of temperature, humidity and wind. Time variation in temperature, humidity and winds.

1 hour

Precipitation. Formation of precipitation, forms of precipitation, types of precipitation, artificially induced precipitation. Precipitation gages and network, satellite estimates of precipitation, interpretation of precipitation data: estimating missing precipitation data, double mass analysis, average precipitation over area, depth area duration analysis.

1 hour

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. **Water Well Pumps.** Variable displacement pumps, positive displacement pumps, pumps used to circulate drilling fluids, airlift pumping, pump selection, water storage. well and pump maintenance and rehabilitation.

1 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.

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

1 hour

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: II *EGE 555*

Course Title: Site Investigation and Foundation Engineering Full Marks: 50
Course No.: EGE 555 Pass Marks: 25
Nature of the course: Theory
Credit 2 (30 hrs)

COURSE CONTENTS

SITE INVESTIGATION

Planning and Procurement for a Project. Introduction, Objectives, General design philosophy, Implementation, Planning ground investigations, Procurement, Execution.

1 hour

Description and Classification of Soils and Rocks. Introduction, Soil and rock description, Soil description, Soil classification, Rock description, Description of rock material, Description of discontinuities, Methods of collecting discontinuity data, Discontinuity surveys, Presentation of discontinuity data, Description of rock masses, Records of boreholes, State of recovery of core, Records of trial pits and shafts.

3 hours

The Desk Study and Walk-Over Survey. Introduction, Sources of information for desk studies, Air photography and remote sensing, Satellite remote sensing, The walk-over survey.

2 hours

Subsurface Exploration. *Engineering geophysics*: Introduction, Lateral variability, Profiling, Sectioning, Determination of properties.

1 hour

Subsurface Exploration Boring, Drilling, Probing and Trial Pitting. Introduction, Boring, Drilling, Probing, Examination in situ.

1 hour

Sampling and Sample Disturbance. Introduction, Sample sizes, Soil disturbance, Classification of soil samples, Nepalese practice and standards.

1 hour

Undisturbed Sampling Techniques. Introduction, Contents, Samples from pits and exposures, Drive samplers, Rotary samplers, Sand sampling, Sampler selection.

1 hour

Laboratory Testing. Introduction, The purpose of soil testing, Available tests, Consolidation tests, Accuracy and measuring systems.

1 hour

In Situ Testing. Introduction, Penetration testing, Strength and compressibility testing, Permeability testing.

1 hour

Basic Field Instrumentation for Site Investigation. Introduction, Uses of instrumentation, Requirements for instrumentation, Pore water pressure and groundwater level measurement, Displacement measurement
Other measurements, References and standards.

3 hours

FOUNDATION ENGINEERING

Effective Stress and Short Term and Long Term Stability. Definition of effective stress, The nature of effective stress, The principle of effective stress, The computation of effective stress, Short-term and long-term stability.

1 hour

Shear Strength. The definition of shear strength, The nature of shear strength, The measurement of shear strength.

1 hour

Immediate Settlement. Introduction, The use of elastic theory in soil mechanics, Elastic stress distributions, Elastic settlements, Heave of excavations, Estimates of undrained modulus, The effects of heterogeneity and anisotropy, Seismic methods for measuring ground stiffness.

2 hour

Bearing Capacity of Shallow Foundations. Introduction, Basic Definitions, Gross and Net footing Pressure, Rankine's Analysis, Hogentogler and Terzaghi's Analyis, 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, Heave of the Bottom of the Cut in Clay, Foundations on Layered, Clay, 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, Consolidation Settlement in Clays, Settlement of foundations on Cohesionless Soils, Accuracy of foundation Settlement Prediction, Allowable Settlement, Allowable Soil Pressure for Cohesionless Soils, Allowable Soil Pressure for Cohesive Soils, Presumptive Bearing Capacity, Plate Load Test, Housel's Method for design of Foundation, Illustrative examples and numerical.

6 hours

Settlement Analysis. Introduction, Consolidation settlements of clays, Prediction of primary consolidation settlement, Secondary settlement, Other methods of predicting settlement, The prediction of settlements on granular deposits, Allowable settlements.

2 hours

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

1 hour

Introduction to combined footings and mat foundation, Foundation on collapsible and expansive soils.

1 hour

Examples and project works for foundation analysis 1 hour

TEXT AND REFERENCE BOOKS

1. Arora. K.R. (2011). Soil Mechanics and Foundation Engineering. Standard Publishers Distributors. Delhi, India. 886p.
2. Murthy, V.N.S. Advance foundation engineering, *CBS publishers and distributors, India.*
3. Clayton, C R.I., Matthews, M.C. and Simons, N.E. Site Investigation, Second Edition, Department of Civil Engineering, University of Surrey, *Oxford [England]; Cambridge, Mass., USA : Blackwell Science, 584 p.*
4. Lambe T. W. and Whiteman R. V. (2000). Soil Mechanics, SI Version, *John Wiley & Sons.*

REFERENCE BOOK

1. Lambe T. W. and Whiteman R. V. (1969). Soil Mechanics, *John Wiley & Sons 553 p.*

SEMESTER: II *EGE 556*

Course Title: Exploration Drilling and Blasting Full Marks: 50
Course No.: EGE 556 Pass Marks: 25
Nature of the course: Theory
Credit 2 (30 hours)

COURSE DESCRIPTION

Understanding the dynamic fracture behaviour of rock is a key step in quantifying response of rock mass to high-energy transient loads such as in drilling and crushing of rock, and fragmentation due to explosive action. This is integral to all civil and mining excavation activities, and determines the safety, economic success, and viability of these operations.

OBJECTIVES

General Objectives. To equip students with in-depth knowledge of drilling and blasting and related function to conduct rock breaking operations in such a way that maximum technical and economic value is created.

Specific Objectives

To provide the students in-depth knowledge of

- Rock drilling and drill bits,
- Explosives and their charging and firing,
- Transportation of explosives,
- Blasting and its mechanism and methods, and
- Effects of blasting due to blasting.

COURSE CONTENTS

Principles of Drilling. Principles of rock drilling, drillability, drillability index, factors affecting the drillability, Approaches of drilling, drilling application, drilling and sampling in rocks, drilling tools, drilling process, drilling and sampling in soils, daily drilling records, probe drilling.

5 hours

Drill Bits. Various types of drill bits and their design aspects. Study of bit life, factors affecting the bit life. Introduction to drilling methods: Rotary, Rotary percussion, percussion, auger drillings.

4 hours

Explosives. Historical Development, properties of explosives, Low and High explosives.

3 hours

Firing of Explosives. Safety fuses, Detonating cord and accessories, Detonators, Exploders. Electric firing and non-electric firing, Electronic Detonators.

3 hours

Blasting Methods. Preparation of charge, stemming and shot firing. Choice and economical use of explosives.

2 hours

Handling of Explosives. Surface and underground transport of explosives, bulk transport in quarries. Storage and handling of Explosives. Magazines, Accidents due to explosives. Precautions and safety measures during transportation.

5 hours

Mechanics of Blasting. Factors affecting rock breakage, Crater theory and its applications, theories of rock breakage using explosives.

4 hours

Effects of Vibration. Vibrations due to blasting and damage criteria, controlled blasting methods, design of blasting rounds, Air overpressure and Fly Rock.

4 hours

TEXTBOOKS

1. Das, S.K. (1993). Explosives and Blasting Practices in Mines. Lovely Prakashan, Dhanbad.
2. Pradhan, G.K. (1996). Explosives and Blasting Techniques. Minetech Publications.
3. Bhandari, S. (1998). Engineering Rock Blasting operations. Chapter 3 and 6, A.A. Balkema, Rotterdam,

REFERENCE BOOKS

1. Mohanty, B. (1996). Rock Fragmentation by Blasting. Chapter4, *A.A. Balkema, Rotterdam.*
2. Sastry, V.R. (1993). Advances in Drilling and Blasting. Chapter 1 and 2, *Allied Publishers Ltd.*
3. Karanam, U.M. Rao and Mishra, B. (1998). Principles of Rock Drilling, *Chapter 1 and 2 Oxford and IBH.*
4. Brookfields, 1997 "Principles of Rock Drilling" *Chapter 1 and 2 Oxford and IBH.*

SEMESTER: II *EGE 557*

Course Title: Practical I: Rock Mechanics Full Marks: 25
Course No: EGE 557 Pass Marks: 12.5
Nature of the Course: Practical
Credit: 1 (45 hrs)

PRACTICAL FOR ROCK MECHANICS

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 hammer rebound hardness of rock 3 hours

Lab 5: Determination of swelling and slake durability of specimen 3 hours

Lab 6: Determination of point load strength index of intact rock 6 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 shear strength and triaxial compression strength of rock 9 hours

Lab 10: Determination of modulus of elasticity and poission ratio 6 hours

TEXT BOOKS

1. Sivakugan N., Arulrajah A., Bo M.W. (2011), Laboratory testing of soils, rocks, and aggregates, *J. Ross Publishing, USA, 624p.*
2. Hoek, E. (2000) Rock Engineering: course note *by E. Hoek. 313p.*

REFERENCE BOOKS

1. ISRM: "Rock Characterization, Testing and Monitoring", *ISRM Suggested Method, Editor E. T. Brown. Pergamon press, 1981.*
2. ASTM: "1985 Annual Book of ASTM Standards", *Volume 04.08: Soil and Rock; Building Stones. Published by ASTM in 1986.*
3. 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 *EGE 558*

Course Title: Practical II: Soil Mechanics — Full Marks: 25
Course No: EGE 558 — Pass Marks: 12.5
Nature of the Course: Practical
Credit: 1 (45 hrs)

SOIL MECHANICS

Lab 1: Determination of water content of a sample by a) oven-drying method, and b) pycnometer method
3 hours

Lab 2: Determination of specific gravity of solids by a) the density bottle method, and b) pycnometer method
3 hours

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
3 hours

Lab 5: Determination of liquid limit and plastic limit of a soil specimen, shrinkage limit of a specimen of the remoulded soil
6 hours

Lab 6: Determination of permeability of soil by a) constant-head permeameter, and b) the variable head permeameter
6 hours

Lab 7: Consolidation test of various soil specimens
6 hours

Lab 8: Unconfined compressive strength of a cohesive soil
3 hours

Lab 9: Strength, cohesion and friction using Mohr-Coulomb failure criteria, from direct shear test and triaxial testing of soils
6 hours

Lab 10: Compaction characteristic of a soil specimen by Proctor's test
3 hours

Lab 11: California Bearing Ratio (CBR) of a soil specimen.
3 hours

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 *EGE 559*

Course Title: Practical III: Applied Geophysics — Full Marks: 25
Course No.: EGE 559 — 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 *EGE 560*

Course Title: Practical IV: Engineering Hydrology and Hydrogeology Full Marks: 25
Course No.: EGE 560 Pass Marks: 12.5
Nature of the course: Practical
Credit 1 (45 hrs)

ENGINEERING HYDROLOGY AND HYDROGEOLOGY

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: II *EGE 561*

Course Title: Field Work (15 days) Full Marks: 50
Course No.: EGE 561 Pass Marks: 25
Nature of the course: Field
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 *EGE 611*

Course Title: Slope Stability Analysis Full Marks: 50
Course No.: EGE 611 Pass Marks: 25
Nature of the Course: Theory
Credit: 2 (30 hrs)

COURSE CONTENTS

GENERAL SLOPE STABILITY CONCEPTS

Introduction, Aims of Slope Stability Analysis, Natural Slopes, Engineered Slopes. 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, Groundwater Conditions, Seismicity, Subsurface Model and Back-Analysis for Slope Stability.

SLOPE MATERIALS

Introduction, Types and Characteristics of Geologic Soil Deposits, Alluvial Deposits, Glacial Deposits, Eolian Deposits, Residual Deposits, Colluvial/Talus Deposits, Marine Deposits, Melanges, Types and Characteristics of Rocks: Shales, Sandstones, Limestone and Related Carbonate Rocks, Igneous Rocks, Pyroclastic Volcanic Rocks, Metamorphic Rocks, Geologic Features Associated with Slopes, Soil/Rock Fabric, Geological Structures, Discontinuities, Groundwater, Ground Stresses, Weathering, Preexisting Landslide Activities, Clay Mineralogy, Seismic Effects, Landslides, Landslide-Prone Occurrences, Fundamentals of Landslides, Useful Clues to Landslide Investigations and Identifications.

GROUNDWATER IN SLOPE

Field Identification and Interpretation of Groundwater Conditions, Groundwater in Slope Stability Analysis: Developing a Groundwater Model from the Field Data, Groundwater Effects on Slope Stability, Groundwater in Rock, Monitoring of Groundwater Pressures, Piezometers and Observation Wells, Installation of Piezometers, Fluctuating Groundwater Levels, Other Instruments-Rainfall Gages.

SLOPE STABILITY CONCEPTS

Introduction, Modes of Failure, Factor of Safety Concepts, Pore Water Pressures, Phreatic Surface, Piezometric Surface, Negative Pore Pressures, Block Analysis, Infinite Slope Analysis: Infinite Slopes in Dry Sand, Infinite Slope in c-ϕ, Soil with Seepage, Planar Surface Analysis: Planar Surface Example, Circular Surface Analysis: Circular Arc ($\phi_u = 0$) Method, $\phi_u = 0$ Example, Friction Circle Method, Friction Circle Example, Method of Slices: Ordinary Method of Slices (OMS), Simplified Janbu Method, Simplified Bishop Method, Generalized Limit Equilibrium (GLE) Method, Janbu's Generalized Procedure of Slices (GPS), Method of Slices-An Example, Control of Negative Effective Stresses, Comparison of Limit Equilibrium Methods, Selection and Use of Limit Equilibrium Methods: Essential First Four Steps, Selection of Analysis Method, Considerations for All Types of Analyses, Design Charts: Historical Background, Stability Charts, Seismic Analysis: Pseudostatic Method, Newmark's Displacement Method, Computed Permanent Displacements, Tolerable Permanent Displacements, Factors Affecting Slope Stability Analysis: Effect of Tension Cracks on Stability Analysis, Effects of Vegetation, Foundation Loads on Slopes, Three-Dimensional Analysis, Rock Slope Stability.

THE FINITE ELEMENT METHOD (FEM) IN SLOPE STABILITY

Example of FEM Analysis of Slopes, Computer Analysis, Available Computer Programs, Introduction to SEEP/W, SLOPE/W and SIGMA/W of GeoStudio Packages.

PROBABILISTIC ANALYSIS OF SLOPES

Sources of Uncertainty, Basic Probability Concepts, Reliability Index, Probabilistic Formulation for Slopes, Probabilistic Analysis of Performance Function, Quantifying Uncertainty.

SLOPE STABILIZATION METHODS

Introduction, Unloading, Excavation, Lightweight Fill, Buttressing, Soil and Rock Fill, Counterberms, Shear Keys, Mechanically Stabilized Embankments, Pneusol (Tiresoil), Drainage, Surface Drainage, Subsurface Drainage, Reinforcement: Soil Nailing, Stone Columns, Reticulated Micropiles, Geosynthetically Reinforced Slopes, Retaining Walls, Gravity and Cantilever Retaining Walls, Driven Piles, Drilled Shaft Walls, Tieback Walls, Vegetation: General Design Considerations, Vegetation Species, Erosion Control Mats and Blankets, Biotechnical Stabilization, Surface Slope Protection, General Design Considerations, Shotcrete, Chunam Plaster, Masonry, Rip-Rap, Soil Hardening, Compacted Soil-Cement Fill, Electro-osmosis, Thermal Treatment, Grouting, Lime Injection, Preconsolidation, **Rock Slope Stabilization Methods:** Removal of Unstable Rock, Catchment, Flattening of Slop, Buttresses, Surface Protection, Reinforcement, Drainage, High performance netting, Use of Explosives, Rock Slope Stabilization Case Histories, **Alternatives to Slope Stabilization:** Complete Removal of Slide Zone, Facility Relocation, Bridging, Selection of Stabilization Methods: Goals, Technical Constraints, Site Constraints, Environmental Constraints, Aesthetic Constraints, Schedule Constraints, Other Constraints, Cost, Introduction to Cost Analysis of Stabilization work.

ROCK SLOPE STABILITY
Effects of discontinuities on slope stability , Orientation of discontinuities, Stereographic analysis of Join data, Pole, point, contour data, Great circles , Lines of intersection, Identification of modes of slope instability Kinematic analysis, Plane failure, Wedge failure , Toppling failure, Friction cone, Applications of kinematic analysis, Example Problem: stereoplots of structural geology data, Example Problem : slope stability evaluation related to structural geology.

Scale effects and rock strength, Examples of rock masses, Shear strength of discontinuities, Definition of cohesion and friction, Friction angle of rock surfaces, Shearing on an inclined plane, Surface roughness, Discontinuity infilling, Influence of water on shear strength of discontinuities, Shear strength of rock masses by back analysis of slope failures, Hoek–Brown strength criterion for fractured rock masses.

PLANE FAILURE ANALYSIS
General conditions for plane failure, Reinforcement of a slope, Seismic analysis of rock slopes, Example of probabilistic design, Example Problem: plane failure-analysis and stabilization.

WEDGE FAILURE ANALYSIS
Definition of wedge geometry, Analysis of wedge failure, Wedge analysis including cohesion, friction and water pressure, Wedge stability charts for friction only, Comprehensive wedge analysis.

CIRCULAR FAILURE
Conditions for circular failure and methods of analysis, Shape of slide surface, Stability analysis procedure, Derivation of circular failure charts, Location of critical slide surface and tension crack, Example of circular failure analysis, Introduction of Stability analysis of circular failures, Example Problem: circular failure analysis.

TOPPLING FAILURE
Types of toppling failure, Kinematics of block toppling failure, Limit equilibrium analysis of toppling on a stepped base, Stability analysis of flexural toppling, Example Problem : toppling failure analysis .

TYPICAL STABILITY ANALYSIS
Rock mass failure, Plane failure-daylighting and non-daylighting, Wedge failure-daylighting and non-daylighting, Toppling failure—block and flexural, Flexural buckling failure.

STABILIZATION OF ROCK SLOPES
Causes of rock falls, Rock slope stabilization programs, Stabilization by rock reinforcement, Stabilization by rock removal, Resloping and unloading, Trimming, Scaling, Rock removal operations, Rock nets, Protection measures against rock falls. Introduction to movement monitoring.

TEXT BOOKS

1. Lee W. Abramson, Thomas S. Lee, Sunil Sharma, 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, 431p.*

REFERENCE BOOKS

1. J. Michael Duncan, Stephen G. Wright, (2005). Soil Strength and Slope Stability, *John Wiley & Sons, Inc., 280p.*
2. Y.M. Cheng and C.K. Lau, (2008). Slope Stability Analysis and Stabilization (New methods and insight), *Routledge, 241 p.*
3. Denys Brunsden, David B. Prior (editor) (1984). Slope Instability, *John Wiley & Sons, Inc., 620 p*

SEMESTER: III

EGE 612

Course Title: Landslide Engineering Full Marks: 50
Course No.: EGE 612 Pass Marks: 25
Nature of the course: Theory
Credit 2 (30 hours)

LANDSLIDES INVESTIGATION AND MITIGATION

Landslide Descriptions. Landslide classifications and nomenclatures, parts of landslide, Field Investigations for landslides, Use of Inclinometers and Piezometers, Effect of groundwater, Laboratory shear strength measurements on soils for landslide study, Effect of sands and cohesionless soils for landsliding, Effects of clays and cohesive Soils for landsliding, Slope stability analysis, stability margin, Earthquake-induced landslides, Remote Sensing of Landslides.

Remedial and Preventative Options. Landslide occurrences, Landslide impact, Prevention of landslides, Remediation of Landslides, Common Issues in Remediation, Alternatives to Full Remediation of a Landslide, Earthworks, Erosion control Measures, Dewatering systems, Seepage barriers, Retaining Walls, Earth Reinforcement systems, Liquefaction Mitigation Techniques, Slip Surface Strengthening, Case histories of landslide mitigations.

LANDSLIDE HAZARD AND RISK

Landslide Hazard. Introduction, Landslide mechanisms and type, Landslide behaviour, Potential for landsliding, Nature of landslide hazards, Acquiring information: landslide investigation, Landslide susceptibility and hazard assessment, Hazard models, Uncertainty, assurance and defensibility.

Background to landslide Hazard and Risk Assessment. Introduction, Risk, Hazard and vulnerability, From hazard to risk, Risk and uncertainty, Uncertainty and risk assessment, Risk assessment, Landslide risk assessment, Risk assessment as a decision-making tool

Qualitative and Semi-Quantitative Risk Assessment. Introduction, Risk registers, Relative risk scoring, Risk ranking matrices, Relative risk rating, Qualitative risk assessment.

Estimating the Probability of Landslide. 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 of cliff recession through simulation models, Estimating probability through use of stability analysis, Estimating probability.

Landslide Susceptibility and Hazard Analysis. Heuristic qualitative approach, statistical quantitative approach, and deterministic approach with illustrations, Rock fall Hazard Rating System.

Estimating the Consequences. Introduction, Using the historical record, A framework for adverse consequences, Loss of life and injury, Direct and indirect economic losses, Intangible losses, Ground behaviour, Elements at risk, Exposure, Vulnerability, Consequence models, Multiple outcome consequence models, Complex outcomes and uncertain futures.

Quantifying Risk. Introduction, Current annual risk, Cliff recession risk, Comparing the risks associated with different management options, Individual Risk, Societal Risk, Reliability of statistics.

From Risk Estimation to Landslide Management Strategy. Introduction to landslide risk management, Assessment criteria, Acceptable or tolerable risks, Economic risks, Loss of life, Environmental risk, Environmental acceptance criteria, Climate change uncertainty: implications for landslide management, Risk assessment, decision making and consultation, Landslide Risk Assessment in Nepal.

TEXTBOOKS

1. Turner A. K., Schuster R. L, (1996) Landslides: investigation and mitigation, National Academies Press, 673p.
2. Lee E. M., Jones D. K. C. (2004) Landslide risk assessment, *Thomas Telford Limited , 454p.*

REFERENCE BOOKS

1. Landslide Risk assessment, *Editors: Oldrich Hungr, Robin Fell, Rejean Couture, Eirk Eberhardt, Taylor and Francis, London 2005, 771p.*
2. Landslide Hazard and Risk, *Editors: Thomas Glade, Malcolm Anderson, Michael J. Crozier, John Wiley & Sons Ltd, England, 802p.*
3. Landslides: Mass Wasting, *Soil, and Mineral Hazards, Timothy Kusky, Facts On File, Inc. An imprint of Info base Publishing, New York, 128p.*
4. Dahal R.K., 2006, Geology for Technical Students, Bhrikuti *Academic publications, Kathmandu, Nepal, 756p.*

SEMESTER: III *EGE 613*

Course Title: Tunnelling and Underground Excavation Full Marks: 50
Course No.: EGE 613 Pass Marks: 25
Nature of the Course: Theory
Credit: 2 (30 hrs)

COURSE CONTENT

Introduction. Brief history-growth and development of civil excavations, Site investigations – ground and rock characterization, Core drilling, Tomography, Lugeon test, Laboratory testing, Rock composition and ground types, Rock mass classification, Projection of geological model

Ground and Rock Fragmentation-Drilling and Blasting. Introduction, Drilling, Chipping hammers/pneumatic breakers, Explosives, Blasting, Blasting accessories, Properties of explosives, Blasting cost, Safety.

Earth Movers, Excavators and Open-Cut Excavations. Introduction, Classification – earth excavation, loading and casting units, Equipment details, Haulage system, Some developments, Equipment selection, Benching, Channelling/canal construction, Uprooting or blasting stumps, Excavation for foundations, Smooth blasting, Road construction and laying sewage lines, Landfill.

Tunnelling by Conventional Methods. Introduction-function of drives and tunnels, Pre-cursor or prior to driving civil tunnel, Tunnelling techniques, Drilling-drivage techniques with the aid of explosives, Blasting - charging and firing rounds, Muck handling and disposal at the subsurface locale, Ventilation, Driving large-sized drives/tunnels in tough rocks, Tunnelling through soft ground and rocks – conventional methods, Supports for tunnels, Past, present and future of tunnelling technology, Over-break and scaling.

Mechanized Tunneling. Introduction, Classification, Partial-face heading machines, Full-face boring machines, Backup system, Boring system, Rock cutting tools and their types, Cutting head configuration.

Rock mass classification. Introduction, Engineering rock mass classification, Terzaghi's rock mass classification, Classifications involving stand-up time, Rock quality designation index (RQD), Rock structure rating (RSR), Geomechanics classification, Modifications to RMR for mining, Rock tunnelling quality index, Q, Using rock mass classification systems, Estimation of in situ deformation modulus.

Support design for overstressed rock. Introduction, Support interaction analysis, Definition of failure criterion, Analysis of tunnel behavior, Deformation of an unsupported tunnel, Deformation characteristics of support, Estimates of support capacity, The PHASES program, Support interaction analysis using PHASES.

Excavation design in 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.

Excavation design in 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.

Excavation design in 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, Stope wall design-the Mathews stability chart method.

Tunnels in weak rock. Introduction, Deformation around an advancing tunnel, Tunnel deformation analysis, Definition of failure criterion, Analysis of tunnel behavior, Dimensionless plots of tunnel deformation, Estimates of support capacity, Estimate of rock mass properties.

Large Powerhouse Caverns in Weak Rock. Introduction, Rock mass strength, In situ stress conditions, Stresses around underground caverns near the toes of slopes, Determination of steel lining length for pressure tunnels, Pillar size between excavations, Problems in using a concrete arch in weak rock, Crane beams, Choice of cavern shapes, Influence of joints and bedding planes, Design of reinforcement, Estimating support pressures, Design of rockbolt and cable support, Use of shotcrete linings, Support installation sequences, Excavation methods.

Energy, Mine Stability, Mine Seismicity and Rockbursts. Mechanical relevance of energy change, Mining consequences of energy changes, Energy transmission in rock, Spherical cavity in a hydrostatic stress field, General determination of released and excess energy, Mine stability and rockbursts, Instability due to pillar crushing, Thin tabular excavations, Instability due to fault slip, Characterisation of seismic events.

Rock Support and Reinforcement. Terminology, Support and reinforcement principles, Rock–support interaction analysis, Pre-reinforcement, Support and reinforcement design, Materials and techniques.

Mining Methods and Method Selection. Mining excavations, Rock mass response to stoping activity, Orebody properties influencing mining method, Underground mining methods, Mining method selection, Special methods, New Austrian tunnelling method (NATM), NATM case studies, Lee's Tunnelling Method (LTM), Semi-mechanized methods, Barrel vault method, Ground improvement, Use of shotcrete during tunneling, Cut and cover tunneling, Submerged (immersed) tubes/tunnels Pillar supported mining methods, Components of a supported mine structure, Field observations of pillar performance, Elementary analysis of pillar support, Design of a stope-and-pillar layout, Bearing capacity of roof and floor rocks, Stope-and-pillar design in irregular orebodies, Artificially supported mining methods, Techniques of artificial support, Backfill properties and placement, Design of mine backfill, Cut-and-fill stoping, Backfill applications in open and bench stoping, Reinforcement of open stope walls, Longwall and caving mining methods, Classification of longwall and caving mining methods, Longwall mining in hard rock, Longwall coal mining, Sublevel caving, Block caving.

Microtunnelling. Introduction, Pipe jacking, Pilot method, Thrust boring, Slurry microtunnelling machines, Iseki (Unclemole), Herrenknecht microtunnelling system, Developments and challenges in microtunnelling.

Blasting Mechanics. Blasting processes in underground mining, Explosives, Elastic models of explosive–rock interaction, Phenomenology of rock breakage by explosives, Computational models of blasting, Perimeter blasting, Transient ground motion, Dynamic performance and design of underground excavations, Evaluation of explosive and blast performance, Blasting damage in rock, Introduction, Historical perspective, Blasting damage, Damage control, Blasting design and control.

Rockbolts and Dowels. Introduction, Rockbolts, Mechanically anchored rockbolts, Resin anchored rockbolts, Dowels, Grouted dowels, Friction dowels or 'Split Set' stabilizers, 'Swellex' dowels, Load-deformation characteristics.

Shotcrete Support. Introduction, Shotcrete technology, Dry mix shotcrete, Wet mix shotcrete, Steel fibre reinforced micro-silica shotcrete, Mesh reinforced shotcrete, Shotcrete application, Design of shotcrete support.

Rockbolts and Cables. Introduction, Rockbolts, Mechanically anchored rockbolts, Resin anchored rockbolts, Dowels, Grouted dowels, Friction dowels or 'Split Set' stabilizers, 'Swellex' dowels, Load-deformation characteristics, Cables, Bond strength, Grouts and grouting, Cable installation, Cables for slope reinforcement.

Stability of underground excavations. Analytical solutions of underground excavations, Circular excavation, Elastoplastic solution of a circular excavation, Roadway stability and support in underground mining, Controlling factors of roadway stability, Prediction of roadway stability, Strata classifications for roadway supports, Mining-induced stress and overburden failure in longwall mining, Mining-induced stress distribution, Mining-induced overburden failure, Sedimentary structure and mining induced stress redistributions, Lithology changes and mining-induced stress distribution, Joints and mining-induced stress distribution.

Hazards, safety and the environment. Introduction, Potential hazards, Mechanization and automation, Fires, rescue and escape, Occupational hazards (health and physique), Legislation, guidance and norms, Safety and accidents, Conceptual planning, detailed design and evaluation, Risk analysis, Environment, Environment management, Sustainable development, Emergency measures/preparedness, Mining-induced surface subsidence, Types and effects of mining-induced subsidence, Chimney caving, Sinkholes in carbonate rocks, Discontinuous subsidence associated with caving methods of mining, Continuous subsidence due to the mining of tabular orebodies.

TEXTBOOKS

1. Civil excavations and tunnelling– a practical guide-Ratan Tatiya *Published by Thomas Telford Publishing, Thomas Telford Ltd, 1 Heron Quay, London E14 4JD.*
2. Support of underground excavations in hard rock e*. hoek, p.k. kaiser and w.f. bawden*
3. Engineering Geology for Underground Rocks Suping Peng Jincai Zhang, Springer-Verlag *Berlin Heidelberg 2007*
4. Nanda A., Rath R. & Usmani A. (editors) (2015) *Underground storage technologies,* Engineers India Ltd., New Delhi - 110066

REFERENCE BOOKS

1. Rock Engineering Handbook, Evert Hoek. Available in his website.
2. Hoek E. , Brown T. (1980) Underground Excavations in Rock by (Jun 30, 1980)
3. Tatiya R. R. (2005) Surface and Underground Excavations: Methods, Techniques and Equipment, *CRC Press, Tylor and Francis Group, 562p.*

SEMESTER: III *EGE 614*

Course Title: Construction material engineering Full Marks: 50
Course No.: EGE 614 Pass Marks: 25
Nature of the Course: Theory
Credit: 2 (30 hrs)

COURSE DESCRIPTION

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

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, assessing, extracting and management of 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. Definition of construction materials, construction materials-past and present.

Geological Construction Materials. Construction stones: Dimension stones, facing stones, flooring stones, broken stones/ripraps, armourstones, supporting and stabilizing stones, filling stones. Coarse aggregates: Definition, crushed stones/ gravel, and natural sand and gravel. Fine aggregates: Definition and uses of fine aggregates, mineralogy of fine aggregates, grain size distribution, shape and texture.

Specifications and Testing of Construction Materials: Sampling method and sampling size, physical tests, petrographic examination, mechanical tests, durability and frost susceptibility, physico-chemical tests, chemical and adhesion tests.

Mortar. Introduction, types of mortars, description and classification of mortar sands and fillers. Testing for fines, influence of sand and fines characteristics on mortar properties, UK specifications, specification and practice outside the UK, light weight aggregates used in mortars.

Unbound Pavement Construction Materials. Flexible pavement layer, concrete pavement layer, unbound pavement. Primary and secondary aggregates, resistance to wear, influence of moisture content and grading on aggregate degradation, engineering effects of degradation. Resistance to decay, effects of water migration and specifications.

Bituminous Bound Construction Materials. Types of aggregates used in bituminous composition, desirable properties of aggregates, influence of aggregates petrography on engineering properties: crushing strength, resistance to abrasion, resistance to polishing, resistance to striping, resistance to weathering effects in service, ability to contribute to strength and stiffness of total mix. Detailed requirements: strength, polishing resistance and abrasion resistance. Relationship between mix composition and desirable aggregate properties.

Railway track ballast. Introduction, rock types suitable for track ballast, British practice, European practice, US practice.

Filter Media and Aggregates. Introduction, principle functions of filters, key properties of filter aggregates, testing of aggregates, filter for civil engineering structures.

Riprap. Rock types suitable for ripraps, armourstone, large rock materials used for stabilizing and retaining structures. Soundness, strength, chemical and mechanical durability.

Dimension stones. Introduction, stability of rock facing, important properties of facing stones. Flooring stones, abrasion resistance, skid resistance, resistance to chemical weathering, rock types suitable for flooring stones.

Cement. Clinker, hydration, cement paste structure and concrete properties, portland cements, special purpose and blended cements, non-portland cements.

Sources of Construction Materials. Igneous, metamorphic and sedimentary rocks; Sediments (fluvial, glacial, coastal, marine, fans and talus). Residual soils.

Field Investigation of Construction Material. Prospecting (Regional geological mapping, aerial photo study), exploration (detailed site mapping, geophysical investigation, drilling and pitting), sampling and quality assessment. Reserve estimation. Quarry design and management.

TEXT 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. 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.*

SEMESTER: III *EGE 615*

Course Title: Remote Sensing and GIS Full Marks: 50
Course No.: EGE 615 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 OBJECTIVE:

- To give knowledge and understanding of remote sensing and GIS for various engineering works.
- To prepare remotely sensed data for various geohazard evaluation and prepare data base and modelling in GIS

SPECIFIC OBJECTIVE: To provide the students in-depth knowledge and practical skills of Remote Sensing and GIS.

AERIAL PHOTOGRAPH

Introduction. Development in aerial and space photography, Advantages and limitations of photogeological techniques.

Aerial Photography. Photographic flight mission and layout, Type of aerial photography, Stereoscopy and vertical exaggeration.

Geometric Characteristics of Aerial Photographs. Introduction, Terminology, Mosaic construction, Stereoscopic parallax, Basic geometrical relations of scale, Parallax and heights using vertical photographs.

Instrumentation. Working principle of instruments used for stereo-viewing measuring and plotting, Methods quantitative determination of geological data including strike, dip, stratigraphic thickness, throw etc.

Photo interpretation. Principles. Elements of photo-interpretations geotechnical elements such as drainage, soil, landforms and vegetation, convergence of evidence.

REMOTE SENSING

Concepts and Foundations of Remote Sensing. Introduction. Energy source and radiation principles. Energy interactions in the atmosphere. Energy interactions with earth surface features. Data acquisition and interpretation.

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.

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.

Introduction to GPS and GPS data acquisition.

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)**,** Photogrammetry using Unmanned Aerial Vehicles (UAV) or drones (low cost, high spatial and temporal resolutions and flexibility in survey scheduling)

GIS

Introduction and Overview. Geographic Information Systems, GIS and Maps, Map projections and Coordinate Systems, Projection system followed by Department of Survey (GoN), Spatial Data Models, Data Sources, Data Input and Data Quality, Database Concepts, Geo Processing, Spatial Analysis (Geo spatial and Spatial Analyst), 3D Analyst, raster and vector-based GIS analysis, Project work.

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 BOOK

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: III *EGE 616*

Course Title: Hydropower Engineering Full Marks: 50
Course No.: EGE 616 Pass Marks: 25
Nature of the Course: Theory
Credit: 2 (30 hrs)

COURSE CONTENT

Introduction. *Hydropower development:* historical background, present and future development. Power situation in Nepal and world: thermal, 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:* 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. 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, Francies, 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, 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 *EGE 617*

Course Title: Numerical Modelling and Computer Applications Full Marks: 50
Course No.: EGE 617 Pass Marks: 25
Nature of the Course: Theory
Credit: 2 (30 hrs)

COURSE CONTENTS

Finite Element Method
Introduction, Definition of Finite Element Method, Differential Equation and Weak Form, Variational Principal, Ritz-Galerkin Method (approximate function, Galerkin Method and Ritz Method), Finite Element Method (1-D Problem): Construction of approximate function, Element matrix, Total element matrix and simple example, Finite Element Method (2-D Problem): Construction of approximate function, Element matrix & total element matrix, simple example and Gauss's method of elimination.

Introduction to Computer Programming with MATLAB
Introduction to Programming: Components of a computer, Working with numbers, Machine code, Software hierarchy, Programming Environment: MATLAB Windows, A First Program, Expressions, Constants, Variables and assignment statement, Arrays, Graph Plots: Basic plotting, Built in functions, Generating waveforms, Sound replay, load and save, Procedures and Functions: Arguments and return values, M-files, Formatted console input-output, String handling, Control Statements: Conditional statements: If, Else, Elseif, Repetition statements: While, For, Manipulating Text: Writing to a text file, Reading from a text file, Randomising and sorting a list, Searching a list, GUI Interface: Attaching buttons to actions, Getting Input, Setting Output, Discrete Linear Systems, Characterisation of linear systems, Finite Impulse Response filters, Infinite Impulse Response filters, Frequency response, Spectral Analysis: Filterbank analysis, Fourier analysis, Spectrograms, Filterbank synthesis, Power Spectral Density Function (PSDF) Analysis.

Linear Algebra. Introduction, Matrices, Entering matrices, Matrices with symbolic elements, Entering vectors, Special matrices, Indices, Matrix operations in MATLAB, Solving sets of linear equations, The row reduced echelon form, Solving sets of equations with the Symbolic Toolbox, Numerical aspects of the use of MATLAB, Exercises.

Differential Equations. Solving differential equations, Solving differential equations numerically, Sets of differential equations, The direction field, Plotting of integral curves.
Example of numerical solution, Solving differential equations symbolically, First order differential equations, Sets of first order differential equations, Higher order differential equations, Exercises.

Programming. Some remarks about variables, Writing programs, Programming language constructs, For-loop, If statements, While-loop, Creating programs, Debugging, Structure variables, Exercises.

Simulink. Introduction, Creating a block diagram, Example of a block diagram, Constructing a Simulink model, Running a simulation, Example: Neuron model, Exercises.

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

REFERENCE BOOKS

1. J. N. Reddy, (1993). An Introduction to The Finite Element Method, *Second Edition ed McGraw-Hill, New York*
2. TR Chandrupatla and AD Belegundu (2002). Introduction to Finite Elements in Engineering. *Prentice Hall*
3. MATLAB User's Guide, *The MathWorks, Inc. USA*
4. MATLAB Reference Guide, *The MathWorks, Inc. USA*
5. MATLAB External Interface Guide, *The MathWorks, USA*
6. Interactive Matlab Course, *Endhoven University of Technology, 190 p.*

SEMESTER: III *EGE 618*

Course Title: Practical I: Numerical modelling and Computer applications Full Marks: 25
Course No.: EGE 618 Pass Marks: 12.5
Nature of the course: Practical I
Credit: 1 (45 hrs)

COURSE CONTENTS

Introduction to Programming. Components of a computer, Working with numbers, Machine code, Software hierarchy.
Practical 1. Related with programming and understating basics (3 hours)

Programming Environment. MATLAB Windows, A First Program.
Practical 2. Make 3 simple program (3 hours)

Expressions, Constants, Variables and assignment statement, Arrays.
Practical 3. Prepare a simple program using variables and arrays (3 hours)

Graph Plots. Basic plotting, Built in functions, Generating waveforms, Sound replay, load and save.
Practical 4. Prepare various graphs in MATLAB, (3 hours)

Procedures and Functions. Arguments and return values, M-files, Formatted console input-output, String handling.

Practical 5. Prepare a program for string handling, (3 hours)
Control Statements. Conditional statements: If, Else, Elseif.
Repetition statements. While, For.

Practical 6. Prepare a program with if, else, Elseif, while and for. (3 hours)
Manipulating Text. Writing to a text file, Reading from a text file, Randomising and sorting a list, Searching a list.

Practical 7. Prepare a program to write in text file. (3 hours)
GUI Interface. Attaching buttons to actions, Getting Input, Setting Output, Discrete Linear Systems, Characterisation of linear systems, Finite Impulse Response filters, Infinite Impulse Response filters, Frequency response.

Practical 7. Prepare a GUI interface in a modular program. (3 hours)
Spectral Analysis. Filterbank analysis, Fourier analysis, Spectrograms, Filterbank synthesis, PSDF Analysis.

Practical 8. Prepare a program for Fourier analysis. (3 hours)
Plotting of integral curves, Example of numerical solution, Solving differential equations symbolically, First order differential equations, Sets of first order differential equations, Higher order differential equations.

Practical 9. Prepare a program to plot integral curves and to solve given first order differential equation (3 hours)
Matrix operations in MATLAB, Solving sets of linear equations, The row reduced echelon form, Numerical aspects of the use of MATLAB.

Practical 10. Solve a sets of equations with the Symbolic Toolbox (3 hours)
Simulink. Introduction, Creating a block diagram, Example of a block diagram, Constructing a Simulink model, Running a simulation

Practical 11. Write a program for neuron model (3 hours)

***Final project work*:** A project work in Matlab to solve an engineering geological problem such as, slope stability, landslide hazard analysis, rockmass rating, tunnel over breaks, Report preparation in LaTeX, Different project for individual student

TEXTBOOKS AND REFERENCE BOOKS

1. Chapman S.J. (2002). Matlab Programming for Engineers, *Thomson Learning, USA, 497 p.*
2. MATLAB User's Guide, *The MathWorks, Inc. USA*
3. MATLAB Reference Guide, *The MathWorks, Inc. USA*
4. MATLAB External Interface Guide, *The MathWorks, USA*
5. Interactive Matlab Course, *Endhoven University of Technology, 190 p.*
6. Hahn B. D., Valentine D.T. (2007). Essential MATLAB for Engineers and Scientists, Third edition, *Elsevier, 428 p.*
7. Reddy J. N. (2006). Solutions Manual for An Introduction to The Finite Element Method, *Forth Edition, McGraw-Hill, New York, 420 p.*
8. Greenberg H. J. (2004). A simplified introduction of LaTeX, *University of Colorado at Denver, 146 p.*

SEMESTER: III *EGE 619*

Course Title: Practical II: Construction Material Engineering Full Marks: 25
Course No.: EGE 619 Pass Marks: 12.5
Nature of the course: Practical
Credit 1 (45 hrs)

COURSE CONTENTS

Lab 1: Introduction to stones and aggregates as geological construction materials. Description of physical characteristics and classification of stones and aggregates.

Lab 2: Testing of fine aggregates for grading and fineness modulus.

Lab 3: Testing of coarse aggregates for grading.

Lab 4: Determination of shape indices and texture of coarse aggregates.

Lab 5: Physical testing of coarse/fine aggregates for specific gravity and water absorption.

Lab 6: Testing of mechanical strength of samples of construction material.

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: Methylene blue adsorption value of rocks and aggregate samples.

Lab 13: Determination of deleterious constituents and micropetrographic index for given rock/particle types.

TEXT 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.*

SEMESTER: III *EGE 620*

Course Title: Practical III: Remote Sensing and GIS Full Marks: 25
Course No.: EGE 620 Pass Marks: 12.5
Nature of the course: Practical
Credit 1 (45 hrs)

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 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: GPS data acquisition

Lab 7: Introduction to the general interface available in GIS software (e.g. ArcGIS); Georeferencing scanned map

Lab 8: Digitizing and editing

Lab 9: Spatial analysis, vector based analysis

Lab 10: Spatial analysis, raster based analysis

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 BOOK

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

SEMESTER: III *EGE 621*

Course Title: Practical IV: Landslide and Slope Stability Full Marks: 25
Course No.: EGE 621 Pass Marks: 12.5
Nature of the course: Practical
Credit 1 (45 hrs)

Course Content

Landslide classifications and nomenclatures, parts of landslide.

Rainfall and Earthquake-induced landslides mapping, Landslide inventories.

Slope stability analysis and stability margin

Large-scale landslide topography and associated shallow landslides

Seepage Analysis, Retaining Walls, Check dams, Liquefaction Evaluation of Ground, Case histories of landslide mitigations.

Landslide susceptibility and hazard assessment: Heuristic qualitative approach, statistical quantitative approach, and deterministic approach, Rock fall Hazard Rating System, Validation of hazard maps, Landslide Risk assessment, Risk assessment as a decision-making tool.

Estimating the probability of Landslide hazard in deterministic model, Estimating probability through expert judgement.

FEM Analysis of Slopes, Computer Analysis with available Computer Programs

Kinematic Analysis of rock slopes and underground caverns, RMR and SMR.

Project works: Landslide hazard Assessment and hazard zonation mapping using ILWIS 3.8 software.

TEXTBOOKS

1. Turner A. K., Schuster R. L, (1996) Landslides: investigation and mitigation, A. Keith Autor Turner, Robert L Autor Schuster, National Academies Press, 1996, 673p.
2. Lee E. M., Jones D. K. C. (2004) Landslide risk assessment, *E. M. Lee and D. K. C. Jones, Thomas Telford Limited, 2004, 454p.*
3. Dahal R.K., 2006, Geology for Technical Students, Bhrikuti Academic publications, Kathmandu, Nepal, *756p.*
4. Lee W. Abramson, Thomas S. Lee, Sunil Sharma, Glenn M. Boyce (2002). Stability and Stabilization Methods, *John Wiley & Sons, Inc., 712 p.*
5. J. Michael Duncan, Stephen G. Wright, (2005). Soil Strength and Slope Stability, *John Wiley & Sons, Inc., 280p.*
6. Y.M. Cheng and C.K. Lau, (2008). Slope Stability Analysis and Stabilization (New methods and insight), *Routledge, 241 p.*
7. Denys Brunsden, David B. Prior (editor) (1984). Slope Instability, *John Wiley & Sons, Inc., 620 p*

REFERENCE MATERIALS

1. Various recent paper related with landslide hazard and slope stability published in national and international journals

SEMESTER: III *EGE 622*

Course Title: Field works
Course No.: EGE 622
Nature of the Course: Field works
Credit: 2 (15 days)

Full Marks: 50
Pass Marks: 25

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 landslide 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 geological, engineering geological site investigation, slope stability, landslide engineering, tunnel engineering, hydropower engineering and hydrogeological information along with field visit to validate the collected data. A final project report 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 *EGE 651*

Course Title: Geotechnical Earthquake Engineering Full Marks: 50
Course No.: EGE 651 Pass Marks: 25
Nature of the Course: Theory
Credit: 2 (30 hrs)

OBJECTIVES

General Objectives:

- Provide fundamental knowledge of the nature of earthquakes, the resulting hazards and the local soil effects under the ground motion.
- It will provide 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:

- The course provides the students knowledge to understand the behavior of civil engineering structures during earthquake loading.
- To familiarize the students with the theory and concept to estimate the earthquake induced ground deformations, such as liquefaction effects, settlement, and lateral spreading, given the characteristics of the earthquake.
- To make candidates able to analyze geotechnical structures, such as, shallow and deep foundations, retaining walls, and slope stability that will resist and withstand the earthquake loading using seismic design considerations.

COURSE CONTENTS

Introduction. Introduction to Seismology and Engineering Seismology, Review on Historical Development of Engineering Seismology, Objective and Scope, Earth's Structure, Internal Structure of the Earth, *Density* and Seismic Wave Structure inside the Earth, introduction to plate tectonics and seismicity with special reference to earthquake generation in inter and intra-plate boundaries. Active Tectonics of the Himalaya, active fault systems and their earthquake potential.

Earthquake Generation. Faults, their types and identification, Significance in Earthquake Engineering.

Earthquake. Definition, Mechanics, Causes .and Seimic Waves, Types of Earthquake, Elastic rebound Theory.

Intensity of earthquake. Rossi-Forrel's Scale; Modified Mercalli's Scale, Japan Meteorological Agency's Scale; Mededev-Spoonheuer-Karnik's Scale and Environmental Seismic Intensity Scale and their Drawbacks and Comparison, Magnitude of Earthquake: Richter Local Magnitude; Surface Wave Magnitude; Body Wave Magnitude; Moment Magnitude, Intensity-Magnitude Relationship, Determination of Magnitude, Epicenter, Epicentral Distance, Focal Depth, Focal Mechanism, Earthquake Energy, Cycle, Return Period, and Frequency.

Effects of Earthquake. Ground Shaking, Structural Hazards, Liquefaction, Landslides, GLOFs, Tsunami, Human and Financial Losses.

Global Seismicity. Himalayan-Alpine Belt; Circum Pacific Belt and Mid Oceanic Ridge and Significant Historical Earthquakes of the world, Earthquake forecast and Prediction.

Earthquake Recording. Historical Development of Earthquake Recording Instruments, Seismometer: Basic Principle of Vertical-motion, Horizontal-motion, Strain Seismometer; Broadband seismometer.

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) in Three Dimension.

Ground Motion Parameters. Amplitude, Peak Acceleration, Peak velocity, Peak Displacement, Ground motion Spectra, Seismic Structure of the Earth.

Seismic Hazard Analysis. Laws of Reflection, Refraction, Attenuation, Identification and Evaluation of Earthquake Sources, Deterministic Seismic Hazard Analyses, Probabilistic Seismic Hazard Analyses, Site Effects and Response Spectra as Output from Hazard Assessn1ent, Seismic Micro-zonation.

Introduction, Seismic Hazards
Wave Propagation, Basic Techniques and Principles, Waves in a Semi-Infinite Body, Waves in a Layered Body, Attenuation of Stress Waves.

Dynamic Properties of Soils. Soils subjected to dynamic loading, Measurements of Dynamic Properties of Soils, Stress-Strain, Behavior of Cyclically Loaded Soils.

Site Response Analysis. Local Soil Effect on the Ground Motion, One-Dimensional Site Response analysis, Linear Approach, Non-Linear Approach, Comparison of One-Dimensional Site response Analyses, Soil-Structure Interaction Mechanism of Liquefaction, Liquefaction Susceptibility, Initiation of Liquefaction, Effects of Liquefaction.

Seismic Slope Stability. Earthquake Induced Landslides, Static Slope Stability Analysis, Seismic Slope Stability Analysis, Unit 8 Dynamic Lateral Earth Pressures, Seismic Design Considerations.

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.
3. 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: II *EGE 652*

Course Title: Project Management Full Marks: 50
Course No.: EGE 652 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

PROJECT MANAGEMENT

Introduction. Understanding concept and making project management work in practice. Understanding project management: projects in contemporary organisation, the definition of a Project, why project management, the project life cycle.

Project Initiation. Project evaluation and selection: Criteria for project selection, the nature of project selection, types of project selection, project risk analysis, sources of information for project evaluation-selection, project proposals.

Organising and Staffing. The project office and the team, the staffing environment, the project manager and his role and responsibilities, essence of a project manager (skill requirements), selecting the project manager, the project organisation, choosing an organisational form leadership and team building in the project environment.

Project Planning. The project manager as a planning agent, project planning and its elements, initial project condition and systems integration, the project action plan and milestone schedules, the work breakdown structures and linear responsibility charts, interface management, why do plan fail, project critical success factors. 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.

Project Implementation. Budgeting: Budget and budgeting methods, pricing and cost estimation, estimating pitfalls, the low bidder dilemma.

Scheduling. Introduction, Network techniques: PERT and CPM. Qant Charts, other conventional presentation techniques, 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.

Project monitoring and management information systems (PMIS). Understanding planning, monitoring, and controlling cycle, information needs and reporting, PMIS requirements.

Project Control. Project control and its purpose, types of control process, designs of control systems, control of creative projects, project termination, project evaluation and auditing, project evaluation and its purpose, the project audit: depth and timing, application of the audit report, the project audit life cycle, essentials of audit evaluation. Project termination: Types of project termination, the termination process, project final report.

TEXTBOOKS

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

REFERENCE BOOKS

1. Krezner H. (1987).Project Management - A System Approach in Planning, Scheduling, and Controlling.

SEMESTER: IV
EGE 653

Course Title: Practical I: Geotechnical Earthquake Engineering
Full Marks: 25
Course No.: EGE 653
Pass Marks: 12.5
Nature of the Course: Practical
Credit: 1 (45 hrs)

Course content

Geotechnical earthquake hazards: fault rupture, ground shaking, liquefaction and lateral spreading, landsliding, Amplification of ground motion, Dynamic response analysis on elastic ground, calculation of amplification factor,

Estimating ground motion parameters: Evaluation of the ground motion parameters at a site using following methods:

Method 1: Based on the earthquake hazard estimates presented in NZS 1170.5.
Method 2: Location specific probabilistic seismic hazard analysis (PSHA).
Method 3: Site-specific site-response analysis. Response analysis on multilayered deposits, Soil structure interaction

Identification, assessment and mitigation of liquefaction hazards: Assessment of liquefaction and lateral spreading, Liquefaction Susceptibility Modelling, Calculation of Factor of Safety against liquefaction,

Identification, assessment and mitigation of earthquake induced landslides: Landslide inventory, stability analysis on dynamic load.

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: IV
EGE 654

Course Title: Seminar | Full Marks: 25
Course No.: EGE 654 | Pass Marks: 12.5
Nature of the Course: Assignments and Presentation
Credit: 1 (15 hrs)

COURSE CONTENT

Students will be given topics for seminars and assignments on various subjects during the on-going semester. They must make presentations of the given topics at the class and it will be evaluated by the teacher concerned. Evaluation of the presentation will be made based on the preparation by the student, answers to the asked questions and level of presentation. Assignments will be given the respective teachers individually and must be submitted on the given dates.

SEMESTER: IV *EGE 655*

Course Title: Dissertation Full Marks: 100
Course No.: EGE 655 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 EGE 661

Course Title: Elective I *(Climate Change and Disaster Risk Management)* Full Marks: 50
Course No.: EGE 661 Pass Marks: 25
Nature of the course: Theory
Credit 2 (30 hours)

COURSE CONTENT

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

Climate Change
Climate variability and change, driving mechanisms of climate change, climate change over geological time scales, methods of paleoclimate reconstruction, observed and projected global climate change, climate change in the Nepal Himalaya.

Climate Change Impacts and Vulnerability
Impacts in the Nepal Himalaya: Transportation and infrastructures sectors, water resource and energy, food security, ecosystem and biodiversity, human health. Climate change and geological processes. Vulnerability assessment: hazards and vulnerability assessment, vulnerability assessment methods and mapping, sectoral and geographical vulnerability assessment of Nepal, vulnerability map of Nepal, case studies.

Climate Change Mitigation and Adaptation
Mitigation approaches: energy, transportation, buildings, industry, agriculture, livestock, forest and waste management. Adaptation: 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, mitigation and sustainable development.

Hazard, Risk and Vulnerability
Definition, concept of hazard, risk, exposure and vulnerability, differences between natural and anthropogenic hazards, types of natural hazard, concept of disasters, risk assessment, vulnerability analysis, parameters of vulnerability including socio-economic dimensions, Introduction to water induced disaster (floods, landslide, slope instability and GLOF), other geological disasters (earthquakes and earthquake wave amplifications, tsunami and volcanic eruptions), manmade disasters (fires and forest fires, nuclear and chemical disaster).

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

Disasters in Nepal
Scenario, causes and mitigation measures of Hydro-meteorological and geological disasters in Nepal: Landslides, Floods, Earthquakes, GLOF and Epidemics, spatial distribution of disasters within different morpho-tectonic zones of Nepal, Climate change induced disasters and protection consideration (flood and sediment production, landslides and rock slope failures), documentation of disaster events in Nepal, stakeholders for DRR in Nepal.

Disaster Risk Management and Practices

DRM cycle: pre-disaster activities, post disaster activities, 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

Legislations on Disaster Risk Management

Disaster Risk Management (DRM) in Nepal constitution, DRM in Periodic Plans, Natural calamity act 1982, National strategy of disaster Risk Management, Hygo framework of Action, International legal provisions and experience

PRACTICAL EXERCISES

1. Risk analysis techniques.
2. **Social vulnerability mapping:** Population, Infrastructure, Agriculture, Industry, water resources, tourism etc
3. **Disaster risk analysis tools:** GIS (ILWIS/ArcView), and other tools (SIERA/RADIUS/HAZUS/CRISIS)
4. Landslide and Flood Hazard Mapping

REFERENCE BOOKS

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

REFERENCE MATERIALS

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 *EGE 662*

Course Title: Elective I *(Landfill Engineering and Solid Waste Management)* Full Marks: 50
Pass Marks: 25

Course No: EGE 662
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 *EGE 663*

Course Title:	Elective I *(Engineering Project monitoring, evaluation and Environmental Impact Assessment)*	Full Marks: 50 Pass Marks: 25
Course No:	EGE 663	

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.*