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**

Full Credit: 70 and Full Mark: 1750

SEMESTER II

SEMESTER: II

EGE 551

Course Title: Soil Mechanics
Course No.: EGE 551
Nature of the Course: Theory
Credit: 3 (45 hrs)

Full Marks: 75
Pass Marks: 37.5

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
Course No: EGE 557
Nature of the Course: Practical
Credit: 1 (45 hrs)

Full Marks: 25
Pass Marks: 12.5

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: III *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.*