TRIBHUVAN UNIVERSITY
INSTITUTE OF SCIENCE AND TECHNOLOGY
CENTRAL DEPARTMENT OF GEOLOGY

REVISED COURSE STRUCTURE AND CURRICULUM

II, III & IV SEMESTERS

PREPARED BY:

GEOLOGY SUBJECT COMMITTEE

2074

Course Structure for M. Sc. Geology II, III and IV Semesters

II SEMESTER

II Semester : Applied Geology

S. N.	Course Code	Course Name	Credits	Marks
1	Geo.551	Exploration Geophysics and Geochemistry	4	100
2	Geo.552	Remote Sensing and GIS	2	50
3	Geo.553	Geology of Mineral Deposits	2	50
4	Geo.554	Hydrology and Hydrogeology	2	50
5	Geo.555	Environmental Sedimentology	2	50
6	Geo.556	Practical of Geo.551	2	50
7	Geo.557	Practical of Geo.552 and Geo.553	2	50
8	Geo.558	Practical of Geo.554 and Geo.555	2	50
		Total	**18**	**450**

II Semester: Hydrogeology

S. N.	Course Code	Course Name	Credits	Marks
1	Geo.561	Exploration Geophysics and Geochemistry	4	100
2	Geo.562	Remote Sensing and GIS	2	50
3	Geo.563	Hydrogeochemistry	2	50
4	Geo.564	Hydrology and Hydrogeology	2	50
5	Geo.565	Groundwater Hydrology	2	50
6	Geo.566	Practical of Geo.561	2	50
7	Geo.567	Practical of Geo.562 and Geo.563	2	50
8	Geo.568	Practical of Geo.564 and Geo.565	2	50
		Total	**18**	**450**

II Semester: Mining Geology and Mineral Exploitation

S. N.	Course Code	Course Name	Credits	Marks
1	Geo.571	Exploration Geophysics and Geochemistry	4	100
2	Geo.572	Remote Sensing and GIS	2	50
3	Geo.573	Geology of Mineral Deposits	2	50
4	Geo.574	Exploration Geology	2	50
5	Geo.575	Mining Geology	2	50
6	Geo.576	Practical of Geo.571	2	50
7	Geo.577	Practical of Geo.572 and Geo.573	2	50
8	Geo.578	Practical of Geo.574 and Geo.575	2	50
		Total	**18**	**450**

III SEMESTER

III Semester: Applied Geology

S. N.	Course Code	Course Name	Credits	Marks
1	Geo.611	Rock Slope Engineering and Geo-hazard Management	2	50
2	Geo.612	Paleoclimate and Quaternary Geology	2	50
3	Geo.613	Basin Analysis	2	50
4	Geo.614	Engineering Geology	2	50
5	Geo.615	Practical of Geo.611 and Geo.612	2	50
6	Geo.616	Practical of Geo.613 and Geo.614	2	50
7	Geo.617	Field Work	4	100
		Total	**16**	**400**

III Semester: Hydrogeology

S. N.	Course Code	Course Name	Credits	Marks
1	Geo.621	Groundwater Modeling	2	50
2	Geo.622	Groundwater Basin Management	2	50
3	Geo.623	Hydrogeological Investigation	2	50
4	Geo.624	Mountain Hydrogeology	2	50
5	Geo.625	Practical of Geo.621 and Geo.622	2	50
6	Geo.626	Practical of Geo.623 and Geo.624	2	50
7	Geo.627	Field work	4	100
		Total	**16**	**400**

III Semester: Mining Geology and Mineral Exploitation

S. N.	Course Code	Course Name	Credits	Marks
1	Geo.631	Rock Engineering	2	50
2	Geo.632	Mine Surveying and Mine Development	2	50
3	Geo.633	Drilling and Blasting	2	50
4	Geo.634	Mining Machinery and Transportation	2	50
5	Geo.635	Practical of Geo.631	2	50
6	Geo.636	Practical of Geo.632	2	50
8	Geo.637	Field Work	4	100
		Total	**16**	**400**

IV SEMESTER

IV Semester: Applied Geology

S. N.	Course Code	Course Name	Credits	Marks
1	Geo.651	Techniques of Structural Analysis	2	50
2	Geo.652	Tectonic Geomorphology and Neo-tectonics	2	50
3	Geo.653	Global Tectonics and Seismology	2	50
4	Geo.654	Practical of Geo.651 and Geo.652	1	25
5	Geo.655	Dissertation	4	100
		Total	**11**	**275**

IV Semester: Hydrogeology

S. N.	Course Code	Course Name	Credits	Marks
1	Geo.661	Climate Change and Groundwater	2	50
2	Geo.662	Groundwater Exploitation	2	50
3	Geo.663	Groundwater Resources and Water Laws of Nepal	2	50
4	Geo.664	Practical of Geo.661 and Geo.662	1	25
5	Geo.665	Dissertation	4	100
		Total	**11**	**275**

IV Semester: Mining Geology and Mineral Exploitation

S. N.	Course Code	Course Name	Credits	Marks
1	Geo.671	Mine Design, Planning and Management	2	50
2	Geo.672	Mineral Economics	2	50
3	Geo.673	Mine Environment and Safety Engineering	2	50
4	Geo.674	Practical of Geo.671	1	25
5	Geo.675	Dissertation	4	100
		Total	**11**	**275**

II
SEMESTER
CURICULUM

Geo.551/561/571: Exploration Geophysics and Geochemistry

Semester	**II**
Course Title	**Exploration Geophysics and Geochemistry**
Course Code	**Geo.551/561/571**
Credits	**4**
Teaching hours	**60 hrs.**
Full Marks	**100**
Pass Marks	**50**
Nature of the course	**Theory**

Part A: Exploration Geophysics (Total credits=2, Teaching hours= 30 hrs., Full Marks=50)

Course description: The course deals with the basic methods of geophysical exploration applied to investigate subsurface geology.

General objectives: To provide basic knowledge and understanding of geophysical methods for subsurface geological exploration.

Specific objectives: To expand students' knowledge and skills of geophysical data acquisition, processing and interpretation of different geophysical data.

Course Contents:

Title	Details	Hrs.
Geophysics as a tool for subsurface geological exploration	Geological and physical basis for geophysical methods, Physical properties of geological materials, Geological parameters controlling physical properties of geological materials, Geophysical anomaly, signal and noise	6
Geophysical data acquisition, processing and interpretation	Geophysical data: temporal and spatial data, Geophysical data and time series, Analog versus digital data, digital data recording and sampling theory, Geophysical data in time domain, Fourier transform and geophysical data in frequency domain, Data filtering, convolution and deconvolution, Correlation and autocorrelation, Qualitative and quantitative interpretation of geophysical data, Inversion and foreward modeling	10
Gravity Method	Gravitational potential, Gravity anomaly: regional and residual anomaly, Gravity data reduction, qualitative and quantitative interpretation	2
Magnetic and electromagnetic methods	Basic concepts and definitions, Remnant magnetization and palaeomagnetism, Magnetic data reduction and interpretation, Basic EM theory: Maxwell's law, VLF method	2

Electrical methods	Electrical properties of geological materials, Electrical potential caused by a point source in the subsurface, Electrical potential caused by a point source on the ground surface, Electrical potential caused by two point sources on the ground surface, Quadripole and potential difference at two potential electrodes at the ground surface, Self-potential: cause and application, Resistivity method: Electrode arrays, Electrical sounding and profiling, Mise-a-la mase method, Equipotential line method, Induced polarization: Measurement of IP in time domain and frequency domain, Data processing and interpretation	4
Seismic method	Stress-strain relation and propagation of seismic waves through geological materials, Continuous change of seismic velocity with depth, Group and phase velocity, Coherence, Time-distance relations for horizontal and inclined layers, Seismic refraction: Data processing and interpretation, Seismic reflection: Data processing and interpretation, Microtremor and its application	4
Radioactive method, Ground penetrating radar and Geophysical well logging	Radioactive properties of rock and minerals, Measurement, processing and interpretation of data. Basic theory, Dielectric constants of geological materials, Reflection profiling. Basic concept, Different methods of geophysical well logging	2

Textbooks:

1. Telford, W. M., Geldart, L. P., and Sherrif, R. E. (1990). Applied Geophysics Second Edition, Cambridge University Press, 860p.
2. Dobrin, M. B. and Savi, C. H. (1988). Introduction to Geophysical Prospecting, McGraw-Hill Book Company, 867p.
3. Lowrie, W. (2007). Fundamentals of Geophysics Second Edition. Cambridge University Press, 381p.

Reference:

1. Gubbins, D. (2004). Time series analysis and inverse theory for geophysics. Cambridge University Press, 255p.
2. Kearey, P., Brooks, M. and Hill, I. (2002). An Introduction to Geophysical Exploration. Wiley, 272p.
3. Parasnis, D. S. (1997) Principles of applied geophysics. Chapman and Hall, 429p.

Part B: Exploration Geochemistry (Total credits=2, Teaching hours= 30 hrs., Full Marks=50)

Course description: The course deals with fundamental principles of geochemistry and geochemical exploration methods applied in mineral exploration.
General objective: To provide in-depth knowledge and practical skills on geochemical prospecting and exploration techniques applied to investigate and find out mineral deposits, and their evaluation.
Specific objective: To provide in-depth knowledge and practical skills for the study, analysis and interpretation of

-Geochemical data
-Geochemical prospecting and exploration of mineral deposits
-Laboratory equipment used in geochemical analysis
-Geochemical sampling, sample treatment, and analysis

Course Contents:

Title	Details	Hrs.
Fundamentals of geochemistry	Zonal structure of the earth, composition of the crust, composition of the earth as a whole, primary differentiation of elements, Goldschmidt's rule of geochemical classification of elements. Major elements, trace elements, Goldschmidt's rule of distribution of elements, compatible and incompatible elements, geochemical process, variation diagrams, Stable and radioactive isotopes and their application in geology.	4
Introduction to exploration geochemistry	Definition and other terminologies, basis of geochemical exploration, types of geochemical survey, the geochemical environment, geochemical cycle, geochemical dispersion, mobility of the elements, natural association of the elements, indicator elements, pathfinder elements, pathfinder minerals, geochemical mapping, geochemical distribution pattern, geochemical anomaly, interpretation of geochemical data, relation between various elements..	3
The Primary Environment	Introduction, distribution of elements in the igneous rocks and minerals, primary halos and primary dispersion, geochemical provinces, geochemical association.	2
The Secondary Environment	Introduction, chemical weathering, physical weathering, environmental factors affecting weathering, application of Eh and pH, adsorption, mobility in the secondary environment, water (groundwater, river water, lake water and sediments)	2
Geochemical surveys	Bedrock, residual soil, ridge and spur soil, stream sediment samples, heavy mineral concentrate panning, biogeochemical, geobotanical, ground water and stream water sampling, gas/ vapor and other geochemical surveys (Introduction, orientation	2

	survey, detailed surveys, interpretation of geochemical data)	
Dispersion patterns of deep seated origin (primary dispersion)	**Syngenetic patterns:** larger patterns (or geochemical provinces), local patterns, **Epigenetic patterns**: wall-rock anomalies, wall-rock alterations, leakage anomalies, compositional zoning etc.	3
Surficial dispersion patterns (dispersion)	Weathering, products of weathering, soil profile, factors affecting soil formation, mechanisms of dispersion: mechanical factors, surficial dispersion patterns, anomalies in residual overburden,	3
Geochemical sampling and sample preparation	Sample size, methods of sampling, quality assurance, controls to sample collection, sample preparation: handling of sample, sample size reduction, separation and concentration, sample dividers, sample homogenization, contamination.	4
Laboratory methods of analysis	Criteria for selecting an analytical technique, important terminologies, introduction to analytical techniques: ion-exchange separation, fire assay, AAS, XRF, INAA, ICP-AES/OES, ICP-MS, TIMS, EPMA, LA-ICP-MS, SIMS, PIXE, X-ray Microprobe.	4
Statistical treatment of geochemical data	Introduction, geochemical parameters, frequency of samples, mean, median, mode, background values, threshold value, anomalous value, standard deviation, population, normal and abnormal distribution, histogram, cumulative frequency curve, regional/ local variation, correlation between elements, classification of samples, survey sampling, anomaly detection.	3

Textbooks:

1. Randive, K. R. (2012). Elements of geochemistry, geochemical exploration and medical geology. Research Publishing, 448p.
2. Levinson, A. A. (1974). Introduction to exploration geochemistry, second edition. The University of Michigan, 924p.
3. Mason, B. and Moore, C. B. (1966). Principles of geochemistry. Wiley Eastern Limited, 350p.
4. Hawkes, H.E and Webb, J. S., (1962). Geochemistry in Mineral Exploration, Harper's Geoscience series 415p.

References:

1. Pacal, Z. (ed.) (1977). Geochemical prospecting methods. GEOCHIM.CSSR.UNESCO Postgraduate training course. 83p.
2. Krauskopf, K. B. and Bird, D. K. (1995). Introduction to geochemistry. McGraw-Hill International editions, Earth Science and Geology Series, 645p.
3. Walther, J. V. (2010). Essentials of Geochemistry. Jones and Bartlet (Student Edition), 797p.

Geo.552/562/572: Remote Sensing and GIS

Semester	**II**
Course Title	**Remote Sensing and GIS**
Course Code	**Geo.552/562/572**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

Course Description: The course provides essentials of remote sensing and GIS tools and techniques applicable in geological investigation.
General Objective: To give in-depth knowledge and practical skills on interpretation of aerial photographs, satellite images and analysis together with application of geographic information system (GIS) for various geological applications.
Specific Objective: To make the students able to

- Aerial photo interpretation,
- Satellite imagery interpretation,
- Their use in geology, engineering geology, hydrogeology and mineral prospecting,
- Data preparation, analysis and map production in GIS.

Course Contents:

Title	Details	Hrs.
Introduction to remote sensing	Development in aerial and space photography, Advantages and limitations of photogeological techniques, Changes in conventional geological surveying.	2
Aerial photography	Photographic flight mission and layout, Type of aerial photography, Use of conventional aerial photography, Stereoscopy and vertical exaggeration.	2
Geometric characteristics of aerial photographs	Introduction, Terminology, Mosaic construction and use, Stereoscopic parallax, Basic geometrical relations of scale, Parallax and heights using vertical photographs.	2
Instrumentation	Working principle of instruments used for stereo-viewing measuring and plotting, Methods quantitative determination of geological data including dip, stratigraphic thickness, throw etc.	2
Photo/image interpretation	Principles. Elements of photo/image interpretations geological applications.	1
Space missions and spectrozonal photography	Advances in photographic techniques, Types of camera, Films and filters, Use of spectrozonal photography, Important space photographic missions.	2
Concepts and Foundations of Satellite remote sensing	Introduction. Energy source and radiation principles. Energy interactions in the atmosphere. Energy interactions with earth surface features. Data acquisition and interpretation.	2

Earth resource satellites operating in the optical spectrum	Earth resource satellites operating in the optical spectrum, Multispectral. Landsat satellite program overview. Orbit characteristics of Landsat- 1, -2, and -3, Sensors onboard Landsat-1, -2, and -3, Landsat MSS image interpretation. Orbit characteristics of Landsat-4 and -5. Sensors Onboard Landsat-4 and -5. Landsat TM image interpretation. Landsat-6 planned mission. Landsat ETM image simulation. Landsat-7, Landsat-8. SPOT Satellite Program. Orbit characteristics of SPOT-l, -2, and -3, SPOT HRV image interpretation. SPOT-4 and -5, SPOT-6 and -7, Meteorological satellites. Earth observing system.	2
Multispectral, thermal, and hyperspectral scanning	Across- track and Along-track multispectral scanning. Thermal, and hyperspectral scanning. Thermal radiation principles. Temperature mapping with thermal scanner data. Interpreting thermal scanner imagery.	2
Digital image processing	Image rectification and restoration. Image enhancement. Contrast manipulation. Spatial feature manipulation. Multi-image manipulation. Image classification. Supervised classification. Unsupervised classification. Classification accuracy assessment.	2
Microwave sensing	Radar development. SLAR system operation. Spatial Resolution of SLAR Systems. Transmission characteristics of radar signals. Earth surface feature characteristics influencing radar returns. Interpretation of SLAR imagery. Elements of passive microwave sensing. Passive microwave sensors. Applications of passive microwave sensing, Lidar.	2
GPS and data acquisition	Introduction to GPS, GPS data acquisition, errors in GPS data, applications.	1
GIS Introduction	Definition of GIS, its development and uses, GIS Databases. Data import and export.	1
GIS and Maps	Maps and their characteristics, map projections; coordinate systems; precision and error	1
Spatial data models	Concept of data model; vector and raster data model; topology; TIN data model	1
GIS data sources	Data lnput and Data Quality; Major data feeds to GIS and their characteristics (maps, GPS, images, databases; commercial data); locating and evaluating data; data formats; data quality; metadata	2
Spatial analysis	Spatial interpolation methods; raster and vector analysis; Map overlay; map calculations; statistics; integrated spatial analysis	1
Surface	DEM, slope, aspect, other raster functions	1

Making Maps	Map functions in CIS; map design; map elements; choosing a map type; Exporting map in different format printing a map	1

Textbooks:

1. Miller, V. C. and Miller, C. F. (1961). Photogeology, Mc Graw-Hill, New York,
2. Lillesand, T. M. and Kiefer, R. W. (1994). Remote Sensing and Image Interpretation, John Wiley and Sons, mc, New York.
3. Burrough, P. A. and McDonnell, R. A. (2004). Principles of Geographical Information Systems, Oxford University Press, 333p.

References:

1. Pandey, S. N. T. (1987). Principles and Applications of photogeology, Wiley Eastern New Delhi.
2. Marcolongo, B. and Franco, M. (1997). Photogeology: Remote Sensing Applications in Earth Science, Oxford and IBH Delhi, 195 p.
3. Albert, C. T. L. and Yeung, K. W. (2002). Concepts and Techniques of Geographical Information Systems, Prentice Hall.

Geo.553/573: Geology of Mineral Deposits

Semester	**II**
Course Title	**Geology of Mineral Deposits**
Course Code	**Geo.553/573**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

Course descriptions: The course deals with the principles and processes of formation of mineral deposits.

General objectives: To give in-depth knowledge and understanding of the geology of mineral deposits.

Specific objectives:

a. To provide the students with in-depth knowledge and practical skills for the principles, geological environment of formation of mineral deposits, types and genesis of mineral deposits and uses.

b. To give in-depth information and understanding of the geological control, mineralization process, current status and future prospect of mineral deposits of Nepal Himalaya.

Course Contents:

Title	Details	Hrs.
Principles	Some elementary aspects of economic divisions, historical survey, global distribution of ore deposits, ore mineralization throughout the geological time, classification of ore deposits, uses of common ore minerals the nature and morphology of the principal types of ore deposits, texture and structure of ore and gangue minerals, fluid inclusions, wall rock alteration , some major theories of ore genesis, stages of ore development, geo-thermometry, geo-barometry, paragenetic sequence, zoning and dating of ore deposits.	6
Geological Environment of the Formation of Mineral Deposits	Series of mineral deposits, geosynclinals deposits, platform deposits, depth of formation of deposits, duration of formation of mineral deposits, composition of igneous rocks vs. mineral deposits, sources of material of minerals deposits, methods of studying deposits, ore genesis.	4
Types and Genesis of Mineral Deposits	Magmatic deposits, pegmatite deposits, carbonatite deposits, skarn deposits, albitite-greisen deposits, hydrothermal deposits, pyritic deposits, deposits of weathering, placer deposits, sedimentary deposits, metamorphogenic deposits and examples of the more important types of ore deposits, Known mineral deposits, major prospects and their present status in Nepal.	8
Gemstones	Identification of natural gemstones, precious and semi-precious stones	2

	and synthetic gems on the basis of their physical properties and associated minerals and rocks. Cutting and polishing of gemstones, gemstone mines and industries in Nepal.	
Petroleum, Natural Gas and Coal	Origin and generation of petroleum and natural gas, trapping of oil and gas, types of oil, present status of oil and natural gas exploration in Nepal, Kathmandu methane gas. Coal: Origin and formation of coal deposits, classification of coal, calorific value, coal prospects/deposits and mines in Nepal.	4
Mineral Resources of Nepal	Study of geological controls, mineralization process, current status and specification and future prospect of mineral deposits of Nepal Himalaya.	6

Textbooks

1. Smirnov, V. I. (1989). Geology of Mineral Deposits. Nem Chand and Brothers, 520p.
2. Evans, A. M. (1993). Ore Geology and Industrial Minerals, An Introduction (third edition); Blackwell Scientific Publications, 379p.
3. Craig, J. R., and Vaughan, D. J. (1981). Ore Microscopy and Ore Petrography, John Wiley and Sons Inc., New York, 190p.
4. ESCAP (1993). Atlas of Mineral Resources of Nepal, vol. 9, UN publication.

References:

1. Umeshwar, P. (2000). Economic Geology, 2nd edition, CBS publisher, 319p.
2. Jensen, M. L. and Bateman, A. M. (1981). Economic Mineral Deposits, John Wiley and Sons Inc., New York, 593p.
3. Robb, L. (2005). Introduction to Ore Forming Processes. Blackwell Science Ltd; Blackwell Publishing Company, 372p.
4. Annual Reports of Department of Mines and Geology, Lainchaur, Kathmandu.

Geo.554/564: Hydrology and Hydrogeology

Semester	**II**
Course Title	**Hydrology and Hydrogeology**
Course Code	**Geo.554/564**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

Course Description: This course provides the students with the concepts of Hydrology and Hydrogeology. It deals with the relation between groundwater and geological formations. Rocks as aquifers.

General Objective: To provide in-depth understanding of groundwater and their occurrence in geologic formations.

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

-Groundwater occurrence

-Geologic formations as aquifers

-Methods of calculating groundwater flow

Course Contents:

Title	Details	Hrs.
Introduction to hydrology	Importance of water, physical and chemical properties of water, hydrological cycle, water balance equation.	2
Precipitation	Precipitation formation, occurrence and distribution, static influence on precipitation distribution (altitude, aspect, slope), rain shadow effect, effect of precipitation on groundwater and runoff, rainfall intensity and storm duration. Rainfall measurement (various types of rain gauges); Point measurement to spatially distributed estimation (Thiessen's polygon, hymsometric method, Isohyetal and other smoothed surface techniques), techniques of filling missing rainfall data, rainfall analysis.	4
Evaporation and Transpiration	Available energy, water supply, atmosphere, measurement of evaporation (Lysimeter, Penman etc.), estimation of evaporation (mass balance, canopy interception loss).	4
Runoff	Runoff mechanism (overland flow, base flow, channel flow), Measuring stream flow (velocity area method, continuous stream flow measurement), current meters, hydrograph analysis (hydrograph separation, the unit hydrograph, flow duration curves), frequency analysis.	6

Aquifers	Aquifer and formation of aquifer systems: weathering, erosion, river works, glacial deposits, alluvial aquifers, rock as aquifers; sedimentary Rock, Igneous and metamorphic rock aquifers.	2
Natural spring	Types of natural spring; Groundwater hydrology of natural spring	2
Well Hydraulics	Types of subsurface water, energy contained in groundwater, nature of converging flow, recharge, effects of partial penetration, Darcy's law.	4
Water well drilling and design	Well drilling methods and problems encountered, well casing. Well screens: types of screens. Selection of screens, Determination of well depth, screen length, Installation of well screens, design for domestic wells, design for sanitary protections, conducting a pumping test, well efficiency, major causes of deteriorating well performance and well failure .	5
monitoring	Groundwater monitoring technology	1

Textbooks:

1. Driscoll, F. G. (1995). Groundwater and Wells, 2nd edition, US filter,/ Johnson Screens,St.Paul, Minnesota. 1076pg
2. Fetter, C. W. (1990). Applied Hydrology 2nd edition, CBS Publishers India 592pg.
3. Raghunath, H. M. (2007). Groundwater 3rd edition. New Age Int. publishers. 504pg
4. Sanders, L. L. (1998). Manual of Field Hydrogeology. Prentice Hall. N. Jersey. 381pg.
5. Todd, K. D. and Mays, L. W. (2005). Groundwater Hydrology 3rd edition John Wiley & Sons Inc.,

References:

6. Journals of Nepal Geological Society.
7. Bulletins of the Department of Geology.
8. Jones, G. P. and Rushton, K. R. (1981). Pumping-test analysis, Groundwater Resources Evaluation (Lloyd).

Geo. 555: Environmental Sedimentology

Semester	**II**
Course Title	**Environmental Sedimentology**
Course Code	**Geo.555**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

Course Description: This course provides a comprehensive knowledge on functioning and dynam of contemporary sediment systems and how these systems respond to a range of disturbances.
General Objective: To give in-depth knowledge and understanding of processes and products in various depositional sedimentary environments.
Specific Objectives: To provide the students with in-depth knowledge and practical skills of

- Analysing sediment, their transport and deposition, and dynamics
- Identifying and remedying sediment related problems in environments of deposition

Course Contents:

Title	Details	Hrs.
Mountain Environments	Characteristics. Definition and classification. Mountain sediment cascade. Sediment yields, budget and transfer processes. **Subaerial fans: alluvial and colluvial :** Introduction. Physical processes. Debris-flow-dominated fans. Stream-flow-dominated fans. Natural and climatically induced slope failures.	2
	Glacial system: Major environments**.** Physical processes of ice flow. Glacial flow, basal lubrication and surges. Sediment transport, erosion and deposition by flowingice. **Glacial environment and sediments**. Ice-produced glacigenic erosion and depositional sediments. Glaciofluvial processes on land and within the ice-front.Glacimarine environments. Glacil acustrine environments.	2
	Glacial system and environmental change:fluvioglacial sedimentation and glacier outburstfloods.Slope movements. Impacts on upland sediment systems. Management and Remediation.	2
Fluvial Environments	**Characteristics and controls :** Hydrologic, geomorphic, hydraulic and physical and chemical characteristics. Channel form. The floodplain. Channel belts, Alluvial ridges and avulsion. River channel changes, adjustable variables and equilibrium. Classification of fluvial system.	2
	Pebbly-braided rivers and humid fans : Bedforms and processes. Hydraulic Controls of channel pattern. Sedimentation model for pebbly braided streams. ***Sandy low-sinuosity rivers***. Bedforms, effects of water stage fluctuation, semi-arid ephemeral streams. Channel lags and channelfills. Braid bar deposits. Sedimentation	2

	models for fine-grained braid bar deposits.	
	Meandering rivers: channel processes; classical point-bar model, channel cut-offs, overbank sedimentation and environments. Areas beyond river influence. ***Anastomosed River system***: morphology. Longitudinal variation of anastomosis. Sedimentation and facies model.	2
	Significance of fluvial sedimentary environment : Sediment sources and accumulation processes: Characteristics of fluvial sediments, Sediment provenance and source material finger prints. Controls on sediment supply, transport and accumulation.	2
	Processes and impacts of anthropogenic activities : Anthropogenic impacts on rates of sedimentation. Agriculture, deforestation and afforestation. Mining. River regulation and channelization.Urbanization. **Sediments as sinks for contaminants:** Sediment contaminants. Sediment-borne contaminant transport. Deposition of sediment-borne contaminants. Contaminant remobilization. **Management and restoration of fluvial systems :** Impacts of climate change. Impacts of increasedanthropogenicdisturbance. Other impacts.	2
Lake Environments	**Lakes and sedimentologicalenvironments** : Lake types and classification. Controls on lakeform. Lake stratification. **Sediment sources and sediment accumulation processes**: Sources and characteristics of lake sediments. Suspended particulate matter in lakes.Chemical and biochemical sediment deposition. Temperate lake chemical processes. Saline lake chemical processes.	2
	Controls on lake sediment transport and accumulation: Transport, sedimentation and resuspension. Bottom dynamic conditions in lakes. Post-depositional processes. **Processes and impacts of disturbance events** : Storms and mass movements. Lake-level fluctuations. Lake sediment pollution. Toxicity of chemical water and lakesedimentpollutants. Climate change impact on lakes.	2
Arid Environments	Definition and aridenvironments. Causes of aridity : Climate. Tectonics. Anthropogenic agents. Sediment sources and transport : Significance of weathering in aridregions : Insolation. Moisture. Salt weathering. Zone of net erosion : Slopes. Exposed lake sediment.	2
	Sediment transport by water : Flow characteristics of ephemeralchannels. Sediment transport by wind: Transport zones. Transport processes.	
	Sediment accumulation processes : Desert lakes, playas and sabhkas. Ephemeral streams. Alluvial fans : Stream flow and debris flow processes. Aeolian processes and bedforms. In situ landform modification : Arid region soils. Pavements. Microphytic crusts. Rain beat crusts. Duricrusts.	2
	Natural and anthropogenic impacts on processes: Controls of	

	tectonics, climate and storminess. Water resources and salinization. Soil erosion. Mineral extraction. Aeolian hazards. Water hazards. Salt hazards.	
Deltaic and Estuarine Environments	Introduction. Classification. Sediment sources and sediment processes in deltas and estuaries. Processes and impacts of natural and anthropogenic change in deltas and estuaries. Managing for prevention of environmental change.	2
Coastal Environments	**Temperate coasts:** Sediment sources and sediment accumulation processes. Impact of storms on sediment movement. Impact of human activities on sediment supply. Sedimentology in coastal zone management.	2
	Tropical coastal environments: Distribution and occurrence of coral reefs and mangroves. Sources and characteristics of coral reef sediments. Reef sediment transport and accumulation. Sources and characteristics of mangrove sediments. Management and remediation of coral reef and mangrove sediments.	

Text Books

1. Leeder, M. (2011). Sedimentology and Sedimentary Basinsfrom Turbulence to Tectonics. Wiley-Blackwell Publication. 784p.
2. Leeder, M. (1982). Sedimentology: Process and product. Allen &Unwin, London. 344p.
3. Perry, C. and Taylor, K. (2007). Environmental Sedimentology. Blackwell Publishing. 441p.
4. Freidman G. M. and Sanders J. E. (1978). Introduction to Sedimentology, Wiley, New York.
5. Reading H. G. (1986). Sedimentary environment and facies, Blackwells Oxford, 688 p.
6. Tucker M. E. (1991). Sedimentary Petrology, An Introduction to the Origin of Sedimentary Rocks. Second edition, Blackwells Oxford, 260 p.
7. Tamrakar N. K. (2011). Practical Sedimentology, Bhrikuti Academic Publication, Kathmandu, 232p.

Reference Books

1. Folk, R.L. (1980). Petrology of Sedimentary Rock. Hemphil Publishing Company, Austin Texas, 184p.
2. Reineck H. E. and Singh I. B. (1980). *Depositional Sedimentary Environments*, 2nd edition, Springer Verlag, 549 p.
3. Pettijohn F. J. (1984). Sedimentary Rocks. 3rd edition, CBS Delhi, 628 p.
4. Allen J. R. L. (1985). Principles of Physical Sedimentology, Unwin-Hyman, London, 272 p.
5. Lindholm R. C. (1991). A Practical Approach to Sedimentology, CBS Publishers and Distributors Delhi, 276 p.
6. Collinson, J. D. and Thompson, D. B. (1994). Sedimentary Structures, CBS Delhi, 207 p.

Geo.556/566/576: Practical of Geo.551/561/571

Semester	**II**
Course Title	**Practical of Geo.551/561/571**
Course Code	**Geo.556/566/576**
Subjects	**Exploration Geophysics (1Cr.), Geochemistry**
Credits	**2**
Teaching hours	**90 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Practical**

Part A: Exploration Geophysics (1 Credit, 45 hours)

Lab 1-5: Geophysical data acquisition and presentation (15 practical hours)

Field layouts: Seismic refraction, Self-potential, Resistivity sounding, Resistivity profiling, Graphical method of data presentation, Tabular method of data presentation

Lab 6-7: Data filtering (6 practical hours)

Data in time and frequency domain, Data filtering in time and frequency domain

Lab 8-15: Data Interpretation (24 teaching hours)

Gravity reduction and interpretation, Curve matching and interpreting resistivity sounding data, Preparation of pseudosection of apparent resistivity data, Interpretation of 2D-ERT tomograms, Preparation of travel time curve of seismic data. Identification of direct, refracted and reflected phases from the travel time curves. Interpretation of travel time curves to evaluate geological information.

Part B: Geochemistry (1 Credit, 45 hours)

Lab 1: Familiarization with the Terms and Definitions related to Geochemistry.
Lab 2: (A) Solar system showing all nine planets, Sun and Asteroid
(B) Galaxy, Nebula, Pangaea, Astronomical unit
Lab 3: Internal structure of the earth in detail showing thickness, and average density of crust, mantle and core.
Lab 4: (A) Isotopes of Hydrogen, Oxygen, Carbon, Uranium, Thorium, Rubidium, Lead (B) Daughter elements of ^{235}U, ^{238}U, ^{232}Th, ^{87}Sr, ^{40}K and ^{14}C.
Lab 6: Geochemical cycle: Primary dispersion and Secondary dispersion
Lab 7: Rock cycle
Lab 8: Statistical interpretation of geochemical data by plotting histogram and cumulative frequency curves and determine geochemical parameters (Median, Mode, Mean ($\underline{X}$), Background (Bg) ,Threshold (X^{th}) values, Standard deviation (Sd), Anomalous and Highly/ distinct Anomalous values in (A) Stream sediment survey/ sampling (B) Ridge and spur soil survey, (C) Residual soil survey and (D) Heavy mineral concentrate sampling for placer gold and other heavy minerals.

Lab 9: Geochemical anomaly map and Geochemical contour map of Cu, Pb, Zn, Co, Ni, Sn and W showing their distribution in residual soil and stream sediments to delineate the anomalous areas.
Lab 10: Radiation/ Radioactivity and Alpha, Beta, and Gamma rays and their properties
Lab 11: Various types of radioactivity in the Neutron – Proton diagram
Lab 12: Radiometric age dating of rocks, minerals, archeological artifacts by (A) ^{87}Rb - ^{87}Sr system/ measurement on mica (B) ^{40}K – ^{40}Ar measurement on mica (C) ^{238}U – ^{206}Pb system on Zircon (D) $^{147}Sm\alpha$ – ^{143}Nd and (E) ^{14}C dating methods.
Lab 13: Evaluate the placer gold reserve in the alluvial deposits (terrace and present river beds) by heavy mineral concentrate panning method.
Lab 14: Find out the fineness purity of placer gold
Lab 15: Field survey and mapping of a large alluvial terrace deposit to find its volume and total gold recovery (reserve) and calculate its present monetary value.

References:

1. Hawkes, H. E. and Webb, J. S. (1962). Geochemistry in Mineral Exploration, Harper's Geoscience series 415p.
2. Mason, B. and Moore, C. B. (1966). Principles of geochemistry. Wiley Eastern Limited, 350 p.
3. Exploration and Mining Geology Chapter-14 Exploration Geochemistry and Geobotany, By William C. Peters, John Wiley & Sons. Pp396-428.
4. LePeltier, C. A. (1969) Simplified statistical treatment of geochemical data by graphical representation. Economic Geology vol.64 p545

Geo.557/577: Practical of Geo.552 and Geo.553

Semester	**II**
Course Title	**Practical of Geo.552/572 and Geo.553/573**
Course Code	**Geo.557**
Subjects	**Remote Sensing and GIS (1 Cr.), Geology of Mineral Deposits (1 Cr.)**
Credits	**2**
Teaching hours	**90 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Practical**

Part A: Remote Sensing and GIS (1 Cr., 45 hours)

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.) preparation of geomorphic map.
Lab 4: Analysis of aerial photographs and satellite imageries for understanding their relative applicability in discrimination of rock types and mapping of soil, vegetation, water and geologic structure.
Lab 5: Image rectification and enhancement.
Lab 6: Digital image classification - supervised and unsupervised.
Lab 7: GPS data acquisition and import in GIS.
Lab 8: Introduction to the general interface available in GIS software (e.g. ArcGIS).
Lab 9: Data extraction and data interpolation techniques.
Lab 10: Digitizing and editing.
Lab 11: Spatial analysis, vector-based analysis.
Lab 12: Spatial analysis, raster-based analysis.
Lab 13: Surface analysis.
Lab 14: Linking attribute and spatial database.
Lab 15: Preparation of different thematic maps in GIS

Textbooks:

1. Miller V. C. and Miller C. F. (1961). Photogeology, Mc Graw-Hill, New York,
2. Lillesand T. M. and Kiefer R. W. (1994). Remote Sensing and Image Interpretation, John Wiley and Sons, mc, New York.
3. Peter A. Burrough and Rachael A. McDonnell (2004). Principles of Geographical Information Systems, Oxford University Press, 333p.

References:

1. Pandey S. N. T. (1987). Principles and Applications of photogeology, Wiley Eastern New Delhi.
2. Marcolongo B. and Franco M. (1997). Photogeology: Remote Sensing Applications in Earth Science, Oxford and IBH Delhi, 195 p.
3. Albert, C. T. L. and Yeung, K. W. (2002). Concepts and Techniques of Geographical Information Systems, Prentice Hall.

Part B: Geology of Mineral Deposits (1 Cr., 45 hours)

Lab 1: Study and identification of non-metallic minerals in hand specimens with reference to texture, structure, association, genesis and uses.
Lab 2: Study and identification of metallic minerals in hand specimens with reference to texture, structure, association, genesis and uses.
Lab 3: Study and identification of industrial rocks and minerals in hand specimens with reference to texture, structure, association, genesis and uses.
Lab 4: Study and identification of gemstones/energy minerals in hand specimens with reference to texture, structure, association, genesis and uses.
Lab 5: Study of parts and working principles of ore microscope.
Lab 6: Techniques of preparation of polished section of ore minerals.
Lab 7-9: Study and identification of common ore minerals with reference to ore texture and structure under ore microscope and interpretation on genesis/mode of formation.
Lab 10-11: Study of geo-thermometry/geo-barometry and fluid inclusion related techniques, parameters and calculations.
Lab 12-13: Study of geological controls of important economic mineral deposits of Nepal Himalaya from geological maps and cross-sections (4 hours)
Lab 14-15: Study on specification techniques and uses of metallic/non-metallic/gemstones and industrial rocks and minerals from Nepal Himalaya (5 hours).

Textbooks:

1. Smirnov, V. I. (1989). Geology of Mineral Deposits. Nem Chand and Brothers, 520p.
2. Evans, A. M. (1993). Ore Geology and Industrial Minerals, An Introduction (third edition); Blackwell Scientific Publications, 379p.
3. Craig, J. R. and Vaughan, D. J. (1981). Ore Microscopy and Ore Petrography, John Wiley and Sons Inc., New York, 190p.
4. ESCAP (1993). Atlas of Mineral Resources of Nepal, vol. 9, UN publication.

References:

1. Jensen, A. M. and Bateman, M. L. (1981): Economic Mineral Deposits, John Wiley and Sons Inc., New York, 593p.
2. Umeshwar, P. (2000): Economic Geology, 2nd edition, CBS publisher, 319p.
3. Robb, L. (2005): Introduction to Ore Forming Processes. Blackwell Science Ltd; Blackwell Publishing Company, 372p.
4. Annual Journals of Department of Mines and Geology, Lainchaur, Kathmandu.

Geo.558: Practical of Geo.554 and Geo.555

Semester	**II**
Course Title	**Practical of Geo.554 and Geo.555**
Course Code	**Geo.558**
Subjects	**Hydrology and Hydrogeology (1 Cr.), Environmental Sedimentology (1 Cr.)**
Credits	**2**
Teaching hours	**90 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Practical**

Part A: Hydrology and Hydrogeology, Geo.554 (1 Cr., 45 hours)

Lab 1: Collection and measurement of precipitation data.
Lab 2: Measurement and calculation of discharge, runoff.
Lab 3: Calculations of energy content in groundwater. Piezometric head calculations.
Lab 4: Groundwater flow, flow net maps.
Lab 5: Groundwater recharge, resource estimation from water table fluctuation, basin discharge calculations, volume in storage.
Lab 6: Pumping test calculations of variable discharge data, equal discharge data, step drawdown tests, recovery method, time drawdown graphs, distance drawdown graphs, slug test in wells and calculations. Calculations of transmissivity, storage coefficient, hydraulic conductivity.
Lab 7: Calculations of cone of depression, well efficiency, specific yield,
Lab 8: Selection of screen based on grain size data, sieve analysis, calculation of hydraulic conductivity based on grain size analysis. Screens and their types. Specifications.
Lab 9: Well designing.

References:

5. Driscoll, F. G. (1995). Groundwater and Wells, 2nd edition, US filter,/ Johnson Screens,St.Paul, Minnesota. 1076p
6. Fetter, C. W. (1990). Applied Hydrology 2nd edition, CBS Publishers India 592pg.
7. Raghunath, H.M. (2007). Groundwater 3rd edition. New Age Int. publishers. 504pg
8. Sanders, L. L. (1998). Manual of Field Hydrogeology. Prentice Hall. N. Jersey. 381pg.
9. Todd, K. D. and Mays, L. W. (2005). Groundwater Hydrology 3rd edition John Wiley & Sons Inc.,

Part B: Environmental Sedimentology Geo.555 (1 Cr., 45 hours)
Lab 1: Compositional analysis of sediments from various depositional elements.
Lab 2: Sediment grain size analysis for proportion of silt and clay in sediment.
Lab 3: Facies models of alluvial fan, and fan delta; braided river, meandering river and anastomosing river; a perennial saline lakes and ephemeral playa lakes.
Lab 4: A study of methods to estimate debris flow velocity.
Lab 5 : Analysis of discharge for a river using a flow resistance equation and hydraulic parameters.

Lab 6: Construction of velocity distribution in stream channel and discharge calculation using area-velocity method.
Lab 7: Incipience of sediments using shear stress criteria. Computation of unit bedload discharge using various approaches.
Lab 8: Determining suspended sediment concentration from suspended sediment samples from rivers.
Lab 9: Plotting of sediment rating curve using given data on discharge and suspended sediment concentration of Himalayan rivers from gauge stations.
Lab 10: Key elements on Anthropogenic impact on upland sediment systems-deforestation.

Textbooks:

1. Perry, C. and Taylor, K. (2007). Environmental Sedimentology. Blackwell Publishing. 441p.
2. Einsele, G. (1992). Sedimentary Basins, Springer Verlag, 628p.
3. Leeder, M. (2011). Sedimentology and Sedimentary Basins from Turbulence to Tectonics. Wiley-Blackwell Publication. 784p.
4. Reading H. G. (1986). Sedimentary environment and facies, Blackwells Oxford, 688 p.
5. Tamrakar N. K. (2011). Practical Sedimentology, Bhrikuti Academic Publication, Kathmandu, 232p.

References:

1. Reineck H. E. and Singh I. B. (1980). Depositional Sedimentary Environments, 2nd edition, Springer Verlag, 549 p.
2. Folk, R. L. (1974). Petrology of sedimentary rocks, Hemphill Publishing, Austin, Texas, 184p.
3. Collinson, J. D. and Thompson, D. B. (1994). Sedimentary Structures, CBS Delhi, 207 p.

Geo.563: Hydrogeochemistry

Semester	**II**
Course Title	**Hydrogeochemistry**
Course Code	**Geo.563**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

Course description: This course deals with the chemistry, chemical pollution and remedial measures of groundwater.

Course objectives: Understanding fundamentals of water chemistry, groundwater chemistry, water quality and pollution of groundwater resources and application techniques of remediation of contaminants in sub-surface.

Course Contents:

Title	Details	Hrs.
Groundwater chemistry	Property of water, inorganic and organic solutes, solute concentration, chemical reaction, activity and effective concentration, reaction rate and equilibrium, mineral dissolution and precipitation, aqueous phase reactions, Metal complexes, oxidation and reduction, biochemical redox reactions, sorption , non-polar organic compounds, isotopes stable isotopes and origin of water origins, radioisotopes	10
Water quality	Measurement, chemical analysis, physical analysis, biological analysis, water quality criteria (WHO and Nepal standards), monitoring groundwater quality	4
Groundwater pollution	Sources of pollution (municipal, industrial and agricultural, miscellaneous sources), point and non-point sources, distribution of contaminants in the subsurface, attenuation of pollution, mass transport of pollutants, Physico-chemical properties of organic compounds, sorption and portioning of organic contaminants in soils and sediments,	8
Remediation of contaminants	Contaminant sources, contaminant plume, mass transfer processes in contaminant plume, redox zonations in contaminant plume, relevant physical and chemical properties of contaminants, isotopes fractionation of contaminants.	8

Textbooks:

1. Todd, D. K. and Mays, W. M. (2005). Groundwater Hydrology. John Wiley & Sons, NewYork, 636 p.
2. Domenico, P.A. and F.W. Schwartz (1990). Physical and Chemical Hydrogeology.- J.Wiley& Sons, Chichester.

References:

1. Driscoll, F. (1986). Groundwater and Wells, St. Paul: Johnson Division
2. Fetter, C.W. (1993). Contaminant Hydrogeology. - Macmillan Publishing Company,New York; pp. 458
3. Schwarzenbach, R. P., Gschwend, P. M., Imboden, D. M. (2002). Environmental Organic Chemistry. Wiley Interscience, 1200 pages.
4. Smith, J. A., Witkowski, P. J., Fusillo (1988). Manmade organic compounds in the surface waters of the United States -A review of current understanding.-U.S. Geological Survey, Circular 1007.

Geo.565: Groundwater Hydrology

Semester	**II**
Course Title	**Groundwater Hydrology**
Course Code	**Geo.565**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

Course Description: This course provides the students with the concepts of Groundwater Hydrology. It deals with the groundwater occurrence and well hydraulics.

General Objective: To provide in-depth understanding of occurrence and groundwater flow.

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

- well hydraulics
- aquifer parameters affecting the flow
- environmental factors affecting the groundwater
- artificial recharge of groundwater
- saline water intrusion in coastal aquifer

Course Contents:

Title	Details	Hrs.
General Hydrogeology	Types of aquifers, water table, specific yield, storage coefficients, specific retentions, Reynolds number, Laminar flow, turbulent flow.	3
Groundwater basin	Concept of groundwater basin; stream order; groundwater basin delineation; groundwater budget	3
Groundwater movement	Darcy's law and hydraulic potential; Burnolli's equation; The Steady-state Groundwater Flow Equation; Streamlines and Flow Nets; Regional Flow and Geologic Controls on Flow; Transient Flow; numerical methods; flow in fractured rock	6
Aquifer characteristics	Hydraulic conductivity, specific capacity, aquifer storage and compressibility; unconfined flow; groundwater interaction with streams and lakes	2
Well Hydraulics	Steady and unsteady flow (Thiem and Theis Equations); Multiple well systems; Pump Tests and Slug Tests; Analysis of pumping test data	8
Couples Flow and Transport	Density Driven Flow; Freshwater/Saltwater Interaction; Heat Transport and Groundwater Flow	4
Groundwater and Environment	Groundwater level and Environmental influences; Artificial recharge	4

Textbooks:

1. Todd, D. K. (1980). Groundwater Hydrology (2nd ed), John Wiley &Sons Inc., New York.
2. Raghunath, H. M (1992). Groundwater (2nd ed), Wiley Eastern Limited, New Delhi, India.

References:

1. Gregersen, H. M., Foliott, P. F., Brooks, K. N. (2007). Integrated watershed management. Connecting people to their land and water. CAB International, 201p
2. Relevant journal articles.

Geo.567: Practical of Geo.562 and Geo.563

Semester	**II**
Course Title	**Practical of Geo.562 and Geo.563**
Course Code	**Geo.567**
Subjects	**Remote Sensing and GIS (1 Cr.), Hydrogeochemistry (1 Cr.)**
Credits	**2**
Teaching hours	**90 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Practical**

Part A: Remote Sensing and GIS (1 Cr., 45 hours)

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.) preparation of geomorphic map.
Lab 4: Analysis of aerial photographs and satellite imageries for understanding their relative applicability in discrimination of rock types and mapping of soil, vegetation, water and geologic structure.
Lab 5: Image rectification and enhancement.
Lab 6: Digital image classification - supervised and unsupervised.
Lab 7: GPS data acquisition and import in GIS.
Lab 8: Introduction to the general interface available in GIS software (e.g. ArcGIS).
Lab 9: Data extraction and data interpolation techniques.
Lab 10: Digitizing and editing.
Lab 11: Spatial analysis, vector-based analysis.
Lab 12: Spatial analysis, raster-based analysis.
Lab 13: Surface analysis.
Lab 14: Linking attribute and spatial database.
Lab 15: Preparation of different thematic maps in GIS

Textbooks:

1. Miller V. C. and Miller C. F. (1961). Photogeology, Mc Graw-Hill, New York,
2. Lillesand T. M. and Kiefer R. W. (1994). Remote Sensing and Image Interpretation, John Wiley and Sons, mc, New York.
3. Peter A. Burrough and Rachael A. McDonnell (2004). Principles of Geographical Information Systems, Oxford University Press, 333p.

References:

1. Pandey S. N. T. (1987). Principles and Applications of photogeology, Wiley Eastern New Delhi.
2. Marcolongo B. and Franco M. (1997). Photogeology: Remote Sensing Applications in Earth Science, Oxford and IBH Delhi, 195 p.
3. Albert, C.T.L. and Yeung, K.W. (2002). Concepts and Techniques of Geographical Information Systems, Prentice Hall.

Part B: Hydrogeochemistry (1 Credit, 45 hours)

Lab 1: Calculation of solute concentration in water in different units.
Lab 2: Presenting inorganic chemical data graphically.
Lab 3: Calculation of solubility product, carbonate reactions and alkalinity.
Lab 4: Methods of water quality analysis.
Lab 5: Calculation of contaminants partitioning in different phases.
Lab 6: Characterization of contaminant plume, its redox zonations and mass transport processes.
Lab 7: Isotopes fractionations for water origin and water contaminant sources.
Lab 8: Performing and understanding Leaching tests.
Lab 9: Application of remediation techniques of contaminants.

References:

1. Todd, D. K., Mays, W. M. (2005). Groundwater Hydrology. John Wiley & Sons, New York, 636 p.
2. Domenico, P. A. and F. W. Schwartz (1990). Physical and Chemical Hydrogeology.- J. Wiley & Sons, Chichester
3. Driscoll, F. (1986). Groundwater and Wells, St. Paul: Johnson Division
4. Fetter, C.W. (1993). Contaminant Hydrogeology. - Macmillan Publishing Company, New York; pp. 458
5. Schwarzenbach, R. P., Gschwend, P. M., Imboden, D. M. (2002). Environmental Organic Chemistry. Wiley Interscience, 1200 pages.
6. Smith, J. A., Witkowski, P. J., Fusillo (1988). Manmade organic compounds in the surface waters of the United States -A review of current understanding.-U.S. Geological Survey, Circular 1007.

Geo.568: Practical of Geo.564 and Geo.565

Semester	**II**
Course Title	**Practical of Geo.564 and Geo.565**
Course Code	**Geo.568**
Subjects	**Hydrology and Hydrogeology (1 Cr.), Groundwater Hydrology (1 Cr.)**
Credits	**2**
Teaching hours	**90 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the	**Practical**

Part A: Hydrology and Hydrogeology (1 Cr., 45 hours)

Lab 1: Collection and measurement of precipitation data.
Lab 2: Measurement and calculation of discharge, runoff.
Lab 3: Calculations of energy content in groundwater. Piezometric head calculations and contouring.
Lab 4: Groundwater flow, flow net maps
Lab 5: Groundwater recharge, resource estimation from water table fluctuation, basin discharge calculations, volume in storage.
Lab 7: Calculations of cone of depression, well efficiency, specific yield,
Lab 8: Selection of screen based on grain size data, sieve analysis, calculation of hydraulic conductivity based on grain size analysis. Screens and their types and specifications.
Lab 9: Well designing.

Part B. Groundwater Hydrology (1 Cr., 45 hours)
Lab 1: Preparation of hydrostatigraphic units.
Lab 2: Characterization of various lithostratigraphic units using hydrogeological parameters.
Lab 3: Prepare water table contour maps and determination of flow directions.
Lab 4: Determination of total head, elevation head and pressure heads.
Lab 5: Preparation of hydrogeological maps including water level fluctuation maps.
Lab 6: Assessing groundwater potential maps using borehole data.
Lab 7: Determination of hydrogeologic parameters like hydraulic conductivity, Transmissivity, storage coefficient etc.
Lab 8: Solving problems of well hydraulics.
Lab 9: Calculation of groundwater recharge.
Lab 10: Introducing the use of soft tools to calculate aquifer parameters

Textbooks:

1. Todd, D. K. (1980). Groundwater Hydrology (2nd ed), John Wiley &Sons Inc., New York.
2. Raghunath, H. M. (1992). Groundwater (2nd ed), Wiley Eastern Limited, New Delhi, India.

References:

1. Gregersen, H. M., Ffoliott, P. F., Brooks, K. N. (2007). Integratedwatershed management: connecting people to their land and water. CAB International, 201p
2. Raghunath, H.M. (2015). Ground Water, Third Edition, New Age International, 520p.
3. Sanders, L. L. (1998). A manual of Field hydrogeology, Prentice Hall.
4. Subramanya, K. (2013). Engineering Hydrology (Fourth Edition), Tata McGraw-Hill Education Pvt. Ltd.,
5. Fetter, C. W. (2007). Applied Hydrogeology, Second Edition. CBS Publishers & Distributors Pvt. Ltd.
6. Relevant journal articles.

Geo.574: Exploration Geology

Semester	**II**
Course Title	**Exploration Geology**
Course Code	**Geo.574**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

Course Description: Exploration geology deals with the discovery and establishment of economic values of deposits.

General Objective: To provide in-depth knowledge and understanding of the modern methods of discovering economic deposits and evaluate them.

Specific Objectives: To make the students able to gain knowledge of

- Prospecting and exploration of mineral deposits
- Exploration system and equipment
- Sampling and reserve estimation of mineral deposits.

Course Contents:

Topics	Details	Hrs.
Introduction	Scope of study, Stages of mineral exploration and mine development.	2
Prospecting criteria and guides	Geological criteria, climatic criteria, stratigraphic criteria, facies and lithological criteria, structural criteria, magmagenic criteria, geochemical criteria, geomorphological criteria, geophysical criteria. Geological conditions favourable to prospecting. Geological indicators: Primary dispersion haloes, secondary dispersion haloes, non-geological guides.	6
Prospecting methods	Classification, surface geological and mineralogical methods. geochemical methods, geophysical methods, Choice of prospecting method, prospecting and geological surveying	6
Exploration equipment and systems	The main types of exploration equipment, Factors affecting choice of exploration system, technical and economic analysis of systems, the applicability of different systems to various types of deposit, exploration records	4
Sampling of deposits	Preliminary data, surface, underground and borehole sampling, sampling methods, spacing of samples,	6

	sampling checks, sampling errors, Treatment of samples, testing of samples, assay checks.	
Evaluation of mineral deposits	General concepts and classification of reserves, reference data for reserve estimation, determination of average block indicators, methods of estimating reserves, accuracy of estimates.	6

Textbooks:

1. Marjoribanks, R., (2010): Geological Methods in Mineral Exploration and Mining, Springer-Verlag Berlin Heidelberg, 238p.
2. Babu, S. K. and Sinha, D. K. (1988): Practical Manual of Exploration and Prospecting, CBS Publishers India, 167 p.

References:

1. Kreiter, V. M. (2004): Geological Prospecting and Exploration, University Press of the Pacific, 384p.
2. Barrett, W. M. et al. (2012): Introduction to mineral exploration, Blackwell Publication, 481p.
3. William, C. Peters; Exploration and Mining Geology, Chapter – 14, 15 & 16 pg397 – 488.
4. DMG Annual Reports.
5. Journal & Bulletin of Nepal Geological Society and website.
6. Journal, Economic Geology.

Geo.575: Mining Geology

Semester	**II**
Course Title	**Mining Geology**
Course Code	**Geo.575**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

Course Description: Mining geology is an applied science, which combines the principles of economic geology and mining engineering that deals with the modern knowledge and techniques of mining.

General Objective: To provide in-depth understanding of the modern methods of surface and underground minings.

Specific Objective: To make the students able to understand

- Mining terminologies, technologies and methods of driving mine openings and associated operations,
- Organisation and techno-economic characteristics of mine works, and
- Environmental issues associated with mining.

Course Contents:

Topics	Details	Hrs.
General Information on Mine Openings	Appraisal of exploration data for mining. Mining terminology, Mining Stages, Modes of entry to mineral deposits- adit or tunnel, Incline or vertical shaft. Exploratory surface mining of mineral and placer deposits, Open-pit mining methods, Classification of underground excavations and methods of excavations, Shapes and cross-sectional dimensions of mine openings, Unit operations of mining.	6
Techniques of Driving Mine Openings	Drilling and blasting in excavations of mine openings. Electric power supply. Aeration of faces and drives of development openings. Loading of blasted muck, haulage, and hoisting, Underground support works.	6
Organisation of the drifting cycle	Patterns and methods of work organisations, Mines administration, Calculation of major parameters of the drifting cycle.	3
Organisation and Mechanisation of Underground Excavation	Techniques, High speed driving of cross-cuts and entries. Excavation of inclined workings. Support of junctions.	3

Technical and Economic Characteristics of driving development Workings	Progress in machine driving of development openings. Rate of advance of development openings and labour productivity. Comparison of broad and narrow face driving. Underground mining methods for open stopping sublevel open stopping, Longwall mining, Room and pillar mining, shrinkage stopping and caving. Cycles of operation-drilling, blasting, mucking, support and lining, ventilation, illumination, and drainage.	8
Environmental Issues	Nature and extent of environmental problems due to surface and underground mining. Mine waste management. Role of the geologist at operative mines.	4

Textbooks:

1. Onika, D. (1978). Excavation of Mine Openings, Mir Publishers
2. Boky, B. (1967). Mining, Mir Publishers, 763p
3. Arogyaswami, R. N. P. (1988). Courses in Mining Geology. Third Edition, Oxford and IBH Publishing Company Limited, New Delhi, 695 p.

Geo.578: Practical of Geo.574 and Geo.575

Semester	**II**
Course Title	**Practical of Geo.574 and Geo.575**
Course Code	**Geo.578**
Subjects	**Exploration and Mining Geology**
Credits	**2**
Teaching hours	**90 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the	**Practical**

Contents:

Lab 1: Study of geophysical logs for geological purposes.
Lab 2-4: Interpretation of geophysical data in mineral exploration.
Lab 5: Statistical analysis of geochemical data.
Lab 6-7: Preparation and interpretation of geochemical anomaly maps.
Lab 8: Determination of dip and strike from borehole data and determination of true dip of mineral veins.
Lab 9: Evaluation of mineral deposit: (a) Placer gold in river terraces and (b) Mineralized body.
Lab 10-11: Estimation of rock mass quality Q and classification of rock mass.
Lab 12-13: Design of support system in underground excavation.
Lab 14-15: Methods of computation of ore reserve, tonnage and grade.

Textbooks:

1. Levinson, A. A., (1980). Introduction to Exploration Geochemistry, Applied Publishing Limited., 924p.
2. Babu, S. K. and Sinha, D. K. (1988). Practical Manual of Exploration and Prospecting, CBS Publishers India, 167 p.
3. Hock and Bray J. (1977). Rock Slope Engineering, Institute of Mining and Metallurgy, London, 358p.

Reference books

1. Onika, D. (1978). Excavation of Mine Openings, Mir Publishers.
2. Boky, B. (1967). Mining, Mir Publishers, 763p
3. Quillion, R. M., Bacon, M., Barclay, and Barclay, W. (1984). An Introduction to Seismic Interpretation, Graham and Trotman Limited, p 89
4. Shlumberger log interpretation chart (1988). Schlumberger Educational Services, 150p.
5. Harman, H. L. and Mutmansky, J. M. (2002). Introductory mining engineering, second edition, 570p.

III
SEMESTER
CURRICULUM

Geo.611: Rock Slope Engineering and Geo-hazard Management

Semester	**III**
Course Title	**Rock Slope Engineering and Geo-hazard Management**
Course Code	**Geo.611**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

Course Description: Rock slope engineering deals with the stability of rock slopes, with methods for assessing this stability and with techniques for improving the stability of slopes. The course of geological hazard gives the necessary knowledge and skills of analyzing, mapping and management of geological hazards.
General Objective: To give in-depth knowledge and understanding of the stability of rock slopes, particularly in relation to the characteristics of rock mass, groundwater and slopes. To provide knowledge on understanding and management of geological hazards.
Specific Objective: The course provides in-depth knowledge of the rock slope stability, factors influencing the stability of slopes and probable mitigative measures. Assessment and management of geohazard like earthquake and volcanic hazard, landslide, flood, and GLOF.

Course contents:
Rock Slope Engineering (1 Cr., 15 Hrs.)

Title	Details	Hrs.
Basic mechanics of slope failure	Continuum mechanics approach to slope stability; role of discontinuities in slope failure; friction, cohesion and unit weight; sliding due to gravitational loading; effect of water pressure in a tension crack; reinforcement to prevent sliding; factor of safety of a slope; slope failure for which factors of safety can be calculated, plane failure, wedge failure, circular failure; critical slope height versus slope angle relationships; slopes for which a factor of safety cannot be calculated; toppling failure, raveling slopes; probabilistic approach to slope design,	2
Rock strength properties and their measurement	Scale effects and rock strength, classes of rock strength; shear strength of discontinuities, definition of cohesion and friction angle, 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: Generalized Hoek-Brown strength criterion, Modulus of deformation, Mohr-Coulomb criterion, Determination of □3'max, Estimation of disturbance factor D	2
Groundwater flow in slope	Field identification of groundwater conditions, interpretation of groundwater conditions; groundwater in slope stability analysis,	2

and rock masses	developing a groundwater model from the field data, groundwater effects on slope stability, reduction in shear strength, reduction in frictional strength, effect of seepage direction; groundwater in rock; monitoring of groundwater pressures, piezometers and observation wells,	
Methods of slope stability analysis	**Plane failure**: General conditions for plane failure, plane failure analysis, influence of groundwater on stability, critical tension crack depth and location, tension crack as an indicator of instability, critical slide plane inclination, analysis of failure on rough plane; reinforcement of a slope, Reinforcement with tensioned anchors, Reinforcement with fully grouted untensioned dowels, Reinforcement with buttresses; seismic analysis of rock slopes, performance of rock slopes during earthquakes, Seismic hazard analysis, Ground motion characterization, Pseudo-static stability analysis, Newmark analysis, Example of probabilistic design, Example problems.	2
	Wedge failure: definition of wedge geometry, analysis of wedge failure, wedge analysis including cohesion, friction and water pressure, wedge stability charts for friction only, examples; comprehensive wedge analysis, examples	2
	Circular failure: conditions for circular failure and methods of analysis, shape slide surface, stability analysis procedure, derivation of circular failure charts, groundwater flow assumptions, production of circular failure charts, use of circular failure chats, location of critical slide surface and tension crack, Examples; Detailed stability analysis of circular failures, circular failure stability analysis computer programs, Numerical slope stability analysis	2
	Toppling failure: types of toppling failure, block toppling, flexural toppling, block-flexure toppling; kinematics of block toppling failure; limit equilibrium analysis of toppling on stepped base, block geometry, block stability, calculation procedure for toppling stability of a system of blocks, cable force required to stabilize a slope, factor of safety for limiting equilibrium analysis of toppling failures, example of limit equilibrium analysis of toppling, stability analysis of flexural toppling, Example problems of toppling failure analysis. **Rock fall:** analysis of rock fall hazards, mechanics of rockfalls, possible measures to reduce rockfall hazards, identification of potential rockfall problems, reduction of energy levels with excavation, physical restraint of rockfalls, rock fall control measures; rockfall hazard rating system (RHRS)**,**	2
Slope stability analysis by numerical method	Numerical models, joint material models, rock mass material models; Modeling issues, 2D analysis versus 3D analysis, continuum versus discontinuum models, selecting appropriate zone size, initial conditions, boundary conditions, incorporating water pressure, excavation sequence, interpretation of results; Typical stability analysis, rock mass failure, plane failure, wedge failure, toppling failure, flexural buckling failure; reinforcement, time-dependent	2

	behavior, dynamic analysis	

Geo-hazard Management (1 Cr., 15 Hrs.)

Title	Details	Hrs.
Landslides	Classification, causes, stability of slopes, factor of stability, causes and effects of slope movements, threshold slopes, basic mechanisms of failure, investigation and mitigation of landslides, landslide hazard mapping techniques, landslide risk assessment, landslide control and management. **Rock slope stabilization methods**: Bioengineering techniques for slope stabilization and watershed management. Removal of unstable rock, catchment, flattening of slope, buttresses, surface protection, reinforcement, drainage, 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	2
Flooding and debris flows	***Flooding*:** Flood hydrograph, factors contributing flooding, Flood hazards, Flood disasters, flood frequency analysis, flood hazard mapping techniques. Design of flood control measures. ***Debris flows*:** classification, mechanism of flow, causes and effects, occurrence of debris flow. design of debris flow control measures.	2
Glacial Lake Outburst Flood (GLOF)	Glacier flow including catastrophic flows, rock debris in glaciers, distribution of glaciers in Nepal. *Glacial lakes*: Types, causes of lake creation, factors contributing GLOF, mitigation techniques, potentially dangerous glacial lakes in Nepal, historical GLOFs in the Himalayas and case studies of some devastating GLOFs, glacier hazard in the Nepal Himalayas, GLOF hazard and risk analysis techniques.	2
Personal and group response to hazards	Before the event, dealing with the event and its aftermath, additional impact	2
***Subsidence* and settlements**	Settlement and subsidence, causes of settlements and subsidence, investigation of settlement and subsidence, hazard and risk analyses and mapping for subsidence.	2
Earthquake	Causes of earthquakes, prediction of earthquake; earthquake disasters, seismic risk maps,	2
Volcanic	Volcanoes, distribution of active volcanoes in the world, causes of volcanic eruption, disasters caused by volcanic eruptions, volcano	2

Eruption	hazard maps, volcano risk maps, prediction monitoring and management of volcanoes	

Textbooks:

1. Wyllie, D. C. and Christopher W. M. (2004). Rock Slope Engineering (Civil and mining), Spon Press, 431p.
2. Hoek, E. (2007). Practical rock engineering. Institute of Mining and Metallurgy, 325p.
3. Hock, E. and Bray J.(1977). Rock Slope Engineering. Institute of Mining and Metallurgy, London, 358p.
4. Abramson, L. W., Lee, T. S., Sharma, S. and Boyce, G. M. (2002). Slope Stability and Stabilization Methods. John Wiley & Sons, Inc., 712p.
5. Bryant, E. (2005). Natural Hazards. Cambridge University press. 330p.
6. Deoja, B., Dhital, M., Thapa, B. and Wagner, A. (Eds.) (1991). Mountain risk engineering handbook. ICIMOD, 875p.
7. Bajracharya, S. R., Mool, P. K., and Shrestha, B. R. (2007). Impact of climate change on Himalayan Glaciers and Glacial Lakes, Case studies on GLOF and associated hazards in Nepal and Bhutan. ICIMOD, 119p.
8. Upreti, B. N. and Dhital, M. R. (1996). Landslide studies and management in Nepal. ICIMOD, Kathmandu, 87p.
9. Tamrakar, N. K. (2011). Geo-environmental Hazards. Central Department of Geology, Kirtipur, 170p.
10. Shrestha, A. B. (2008). Resource manual on flash flood risk management,module 2: non-structural measure, ICIMOD, 89p.

References:

1. Brunsden, D. and Prior, D. B. (editor) (1984). Slope Instability. John Wiley & Sons, Inc., 620p.
2. Deoja, B., Dhital, M., Thapa, B. and Wagner A (1991). Mountain Risk Engineering Handbook: Part II – Applications. ICIMOD, 318p.
3. Blasio, F. V. D. (2011). Introduction to the Physics of Landslides: Lecture notes on the Dynamics of Mass Wasting. Springer, 425p.
4. Hencher, S. (2012). Practical Engineering Geology. Spon Press, 450p.
5. Hudson, J. A. (1993). Comprehensive Rock Engineering, Vol.3&5, Pergamon Press, Oxford.
6. Duncan, J. M. and Wright, S. G. (2005). Soil Strength and Slope Stability, John Wiley & Sons, Inc., 280p.
7. Goodman, R. E. (1989). Introduction to Rock Mechanics, Johan Wiley & Sons, New York, 562p.
8. Cheng, Y. M. and Lau, C. K. (2008). Slope Stability Analysis and Stabilization (New methods and insight). Routledge, 241p.
9. Zhu, W. and Zhao, J. (2004). Stability analysis and modeling of underground excavations in fractured rocks. Elsevier, 289p.

Geo.612: Paleoclimate and Quaternary Geology

Semester	**III**
Course Title	**Paleoclimate and Quaternary Geology**
Course Code	**Geo.612**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

Course description: The course provides the students with the understanding of the geological deposits and features in the Quaternary Period, their mapping and classification techniques. It also deals with the study of chronological events, glaciations and environmental changes in Quaternary Period.

General objectives: To give in-depth knowledge and understanding the history of the latest part of the geological time, its influence in climate and relation to biological world in the Earth including hominids.

Course Contents:

Title	Details	Hrs.
Preliminary considerations	General characteristics of the Quaternary (Quaternary, Pleistocence and Holocene).	
Classical Models	The Alpine Model, Northern Europe, British Isles, Central North America and East Africa.	
The Oceanic Record	Sediments of the Pelagic Environment, Oxygen Isotope Analysis, Oxygen Isotope Stratigraphy.	
Classification	The Quaternary and pre Quaternary, Data presentation: climatic curves**,** Stratigraphic classification, Chronostratigraphic classification, Last Interglacial, Last Glaciation, Holocene.	
Geochronometric Dating	Radiocarbon dating, Uranium series Disequilibrium Dating Methods, Potassium- Argona dn $Argon^{40}/Argon^{39}$ Dating, Fission Track Dating**,** Magnetostratigraphy**,** Amino Acid Diagenesis**,** Glacial Varves**,** Nonglacial Annual Deposits**,** Dendrochronology. Quaternary Climate change.	
The Fossil Record	Pollen Analysis**,** Mammalian Faunas**,** Coleoptera**,** Hominids**,** Deep Sea Biostratigraphy	
Sea Level	Factors determining sea level, Pleistocene sea level**,** Late-glacial and	

	Holocene sea levels.	
Glaciation	Models of Glaciation and Deglaciation**,** Pleistocene Depositional Sequences and Landforms.	
Non-glacial Environments	Tephrochronology**,** Palaeosols**,** Periglacial Environments**,** Low Latitude Environments and Fluvial Lakes.	
Overview	Standard Chronostratigraphic scale**,** Means of Correlation. Quaternary Research: 'State of the Art'.	

Textbooks:

1. Bowen, D. Q. (1978). Quaternary Geology: A Stratigraphic Framework for Multidisciplinary Work. Pergamon Press, 240p.
2. Lowe, J. and Walker, M. (2015). Reconstructing_Quaternary Environments. Routledge, Third edition, 569p.
3. Roberts,N. (2014). The Holocene: An environmental history, Wiley-Blackwell, Third edition, 378 p.

References:

1. Journal articles in various national and international journals.

Geo.613: Basin Analysis

Semester	**III**
Course Title	**Basin Analysis**
Course Code	**Geo.613**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**
Credit	**2 (30 hrs.)**

Course Description: Basin Analysis deals with regional to local scale entities of sedimentary basins distributed in the globe. This course provides skills and techniques of data acquisition, analysis and interpretation of sedimentary basins.

General Objective: To give in-depth knowledge and understanding of the structure of the Earth's sedimentary basins in various tectonic settings.

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

− Classification of sedimentary basins
− Origin and occurrence of sedimentary basins
− Data analysis to reconstruct and interpret sedimentary basins

Course Contents:

Title	Details	Hrs.
Types of Sedimentary Basins	**Basins in Plate Tectonic Environment***:* Zonation of the Earth, Plate movements, Wilson Cycle. Mechanisms of basin subsidence.	2
	Tectonic basin classification : Continental or interior sag basins. Oceanic sag basins. Continental or interior fracture basins. Basins on passive continental margins. Basins related to subduction. Basin related to collision. Strike-slip/Wrench basins. Dickinson's Classification. Ingersoll's Classification. Pre-, Syn- and Post-Depositional Basins.	2
Basin Evolution and Sediments	**Rift Basins** : Rift structures : Pure shear and simple shear. Other structural features. Examples of young rift zones : East African Rift Zone. Otheryoung rift zones. Sediments of Rift Basins. Facies models for half-graben basins. Transition from Rift Basins to Continental Margin Basins.	2
	Continental Margin and Slope Basins : Types of continental margins. Basin morphology and sediments. Sediment successions of continental margin basins : Sediment buildup on Atlantic-type margins. Sediment-starved marginal basins. Submarine Marginal Plateaus. Sediment successions on continental slopes.	2
	Intracratonic Basins Associated wtih Mega-Rifting : Permian to Mesozoic Basin development in Europe. Mesozoic Sediments between the North Sea and the Western Tethys. **Continental or Intracratonic Sag Basins :** General Aspects. Sediments.	2

	Deep-seaTrenches, Forearc and Backarc Basins : ***Deep-seaTrenches*** : General characteristics and sediment sources. Consequences for sediments in accretionarywedges. The Sunda Arc-Trench System. ***Forearc Basins*** : Types of Forearc Basins. Basin Evolution and sediment source. Ridged and Shelved Forearc Basins. Sediment Successions of Forearc Basins. Examples : The Great Valley-Forearc Basin of California. ***Backarc Basins*** : General characteristics. Sediment successions of Backarc Basins. Examples of Modern Backarc Basins. Ancient subduction Basins.	2
	Remnant and Foreland Basins : ***Remnant Basins with Flysch***: General. Basin evolution and sediments. ***Foreland Basins with Molasses***: General. Modern Examples. Basin Evolution and Sediments. **Pull-Apart Basins** : General Characteristics. Sediments of Pull-Apart Basins.	2
Depositional Rhythms and Cyclic Sequences	**General Aspects** : Individual beds, rhythmic bedding and sedimentary cycles. Autogenetic and allogenetic processes. Scales of rhythmic and cyclicphenomena. Symmetry and asymmetry of cycles. Cycle hierarchy. Cyclic versus decyclic bedding. Cyclic sequences in lakes. Sediment successions in fluvial and deltaic systems.	2
Basin Mapping Methods	**Sedimentologic-Stratigraphic Database:** ***Describing Surface Sections****:* Method of measuring and recording data, Types of field observation, graphic logging. ***Describing Subsurface Stratigraphic Sections*****:** Method of measuring and recording data, Examination of well cutting and cores, Subdivision of section into descriptive units, Sampling plan. ***Stratigraphic Procedures*****:** Mapping and correlation procedure, Surface mapping, and stratigraphic cross-section matching. 3-D panel diagram.	2
	Application of Log Data in Basin Evaluation**:** Petrophysical logs: Bore hole logging, log combination for effective interpretation.	2
	Clastic Petrographic Data*:* Petrofacies analysis, Provenance analysis. **Paleocurrent Analysis:** Types of paleocurrent indicators, Data collection and processing, Environment and paleoslope interpretation.	2
	Overview on depositional environments. Some general trends for sediment accumulation and facies. **Facies Analysis:** Meaning of facies, Recognition and definition of facies types, Example of facies scheme, Establishing a facies scheme, facies associations and sedimentary models, ordering of facies, Vertical profile analysis.	2

	Structure and Isopach contouring. ***Construction of lithofaciesMaps****:*Multi-component map, Lithofacies assemblage maps, Single component maps.	2
Sedimentation Rates	Sedimentation Rates in Various Depositional Environments. **Sedimentation and Accumulation Rates**: Sedimentation rates. Accumulation rates. Short- and long-term sedimentation rates. Potential and actual sedimentation rates. Average Sedimentation Rates in various depositional environments. Sedimentation rates in relation to denudation, subsidence and sea level change.	2

Textbooks:

1. Miall, A. D. (1984). Principles of Sedimentary Basin Analysis. Third Edition,
2. Springer Verlag, 616p.
3. Allen, P. A. and Allen, J. R. (1990). Basin Analysis: Principles and Applications.
4. Blackwell Scientific Publications, London, 451p.
5. Einsele, G. (1992). Sedimentary Basins, Springer Verlag, 628p.
6. Tamrakar N. K. (2011). Practical Sedimentology, Bhrikuti Academic Publication, Kathmandu, 232p.

References:

1. Nichols, G. (2009). Sedimentology and Stratigraphy. 2nd edition. Wiley-Blackwell, 418p.
2. Reineck H. E. and Singh I. B. (1980). Depositional Sedimentary Environments, 2nd edition, Springer Verlag, 549p.
3. Folk. R. L. (1980). Petrology of Sedimentary Rocks. Hemphill Publishing Company, Austin, Texas,184p.
4. Pettijohn, F. J. (1984). Sedimentary Rocks. 3rd edition, CBS Delhi, 628 p.
5. Yin, A. and Hrrison, T. M. (eds) (1996). The Tectonic Evolution of Asia. Cambridge University Press, 666p.

Geo.614: Engineering Geology

Semester	**III**
Course Title	**Engineering Geology**
Course Code	**Geo.614**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

Course Description: The course deals with engineering properties of geological materials and geological site investigation method for engineering construction.
Objective: To provide knowledge and understanding of engineering properties and classification of geological materials, field and laboratory test of geological materials, instrumentation and site investigation and analysis techniques for master level student.
Contents:

Title	**Content**	**Hrs.**
Introduction and Basis of Engineering Geology	Formation and development of Engineering Geology as subject, Aims and achieving the aims of engineering geology, Engineering geological mass, Geological materials and mass fabric, Environmental Factors, Engineering geological matrix and engineering behavior of ground, and Essential	2
Properties of geological materials	Engineering properties of geological materials –unit weight, density, porosity, permeability, void ratio, strength, deformability-elastic modulus, bulk modulus and modulus of rigidity, Poission's ratio,abrasivity and environmental reactivity;Soil: Particle size analysis: sieve and hydrometer analyses and consistency tests; properties and behavior of coarse soils, silts and loess, clay deposits, dispersive soils, organic soils: peat; properties and engineering aspects of igneous,metamorphic and sedimentary rocks; description of geological materials; mass fabrics, weathering, and ground description.	4
Strength experiments and failure criteria	Soil: shear strength of soil – direct shear box test and tri-axial test, effective stress Rock: Uniaxial tensile test, direct tensile strength test, point load test, Brazilian test, uniaxial compressive strength test, tri-axial strength test, poly-axial compressive test; Rock failure types; Rock failure criteria, Mohr-Coulomb criterion and Hoek-Brown criterion.	2
Classification of geological material	Classification of soil; application of soil classification; rock mass classification: Rock mass rating (RMR), Collection of field data, estimation of rock mass rating and its applications, Rock mass quality Q(Q-system), collection of field data, estimation of support pressures, Geological strength index (GSI), Rock mass number: interrelation	4

	between RMR, Q and GSI.	
Maps section and logs	Maps, maps making, geological and engineering geological maps, types of geological maps and engineering geological maps, geologically hazardous zone maps, Understanding Geological and engineering geological Maps	2
Instrumentation	Reasons for instrumentation, Instruments and applications, Choosing instrumentation, Water pressure measurement - Pressure Gauges, Manometers, Piezometers (with types), Ground movement measurement- leveling stations, Bench marks, Level Gauges, Profile Gauge, Settlement Cells/ Gauge, Strain Meter, Tape Rod Wire Borehole and multiple Extensometers, Tiltmeter, Deflectormeter, and Inclinometer, Accelerometers, Vibration monitoring, and Borehole Periscope. T.V., Camera. 3hr	2
Field tests and measurements	Drilling methods and drilling bit selection for investigation, Tests in boreholes: resistance to penetration, strength and deformation test, permeability test, in situ stress measurement, tests and measurements in excavations and large diameter boreholes, shafts and tunnels, in situ shear test, other tests, and engineering geophysics.	2
Site investigation	*Tunnel:* terminology, tunneling methods, geological condition of tunnelling, methods of site selection (feasibility, detailed and pre-construction stage).	2
	Dam site: terminology and types of dam, geology and dam site, problems and failures in dam, geological investigation of dam site, slope protection of dam site, foundation work for dam, grouting equipment's and methods, site selection criteria for dam (preliminary investigation, detailed exploration, pre-construction stage).	2
	Road: Terminology and classification, road and pavement foundation, rigid and flexible pavement, geological investigation of mountain road, valley road, and road in plane area, road alignment survey.	2
	Railroad: terminology and classification, rail road foundation, geological investigation of railroad in mountain area and plane area.	2
	Bridge: Classification of bridge and parts of bridge, types of abutment, types of piers, bridge foundations, investigation of medium size bridge and large size bridge foundation.	2
	Building: Types of building foundation, residential, commercial and industrial buildings, power plants and pumping stations, Selection of foundation types, foundation problems and exploratory programs, foundation on unstable ground, groundwater problems in foundations, building foundation on fills.	2

Textbooks and References:

1. Bell, F. G. (1980). Engineering Geology and Geotechniques, John Wiley and Sons, New York.
2. Bell, F. G. (1982). Fundamentals of Engineering Geology, Aditya Books Pvt. Ltd., New Delhi, 648p. Beavis F. C. (1985): Engineering Geology, John Wiley and Sons, New York.
3. Price, D. G. (2009). Engineering Geology: Principles and Practice. Springer, 450p.
4. Krynine, D. P. and Judd W. R. (1957). Principles of Engineering Geology and Geotechniques, John Wiley and Sons, New York.
5. Legget K. F. and Hatheway (1988). Geology and Engineering, John Wiley and Sons New York.
6. Hock, E. and Bray J. (1977). Rock Slope Engineering, Institute of Mining and Metallurgy, London, 358p
7. Hoek, E, Kaiser, P. K. and Bawden, W. F. (2005). Support of Underground Excavations in Hard Rock. A. A. Balkema/Rotterdam/Brookfield, 225p.

Geo.615: Practical of Geo.611 and Geo.612

Semester	**III**
Course Title	**Practical of Geo.611 and Geo.612**
Course Code	**Geo.15**
Subjects	**Rock Slope Engineering and Geo-hazard Management (1 Cr), Quaternary Geology (1 Cr.)**
Credits	**2**
Teaching hours	**90 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Practical**

Part A: Rock Slope Engineering and Geo-hazard Management (1 Credit, 45 hours)

Lab 1: Plane failure analysis.
Lab 2: Circular failure analysis.
Lab 3: Topple failure analysis.
Lab 4: Rock fall analysis.
Lab 5: Numerical analysis for plane failure, wedge failure and circular failures.
Lab 6: Landslide hazard Analysis.
Lab 7: Flood hazard Analysis.
Lab 8: GLOF hazard analysis.

Textbooks:

1. Duncan C. Wyllie and Christopher W. Mah, 2004. Rock Slope Engineering (Civil and mining), Spon Press, 431p.
2. Hock, E. and Bray J., 1977. Rock Slope Engineering. Institute of Mining and Metallurgy, London, 358 p.
3. Lee W. Abramson, Thomas S. Lee, Sunil Sharma, Glenn M. Boyce, 2002.Slope Stability and Stabilization Methods. John Wiley & Sons, Inc., 712 p.
4. Bryant, E., 2005. Natural Hazards. Cambridge University press. 330 p.

Part A: Quaternary Geology (1 Credit, 45 hours)

Lab1: Study of chronostratigraphic scale of Quaternary Period.
Lab 2: Study of Quaternary deposits from the Kathmandu Basin.
Lab 3: Study of Quaternary deposits from the Pokhara Basin.
Lab 4: Study of Quaternary deposits from the Thakkhola Basin.
Lab 5: Study of Quaternary deposits from the Indo-Gangetic Plain.
Lab 6: Preparation of Quaternary glaciation map from different parts of the world.

Textbooks:

1. Bowen, D. Q. (1978). Quaternary Geology: A Stratigraphic Framework for Multidisciplinary Work. Pergamon Press, 240p.

2. Lowe, J. and Walker, M. (2015). Reconstructing_Quaternary Environments. Routledge, Third edition, 569p.
3. Roberts,N. (2014). The Holocene: An environmental history, Wiley-Blackwell, Third edition, 378 p.

Geo.616: Practical of Geo.613 and Geo.614

Semester	**III**
Course Title	**Practical of Geo.613 and Geo.614**
Course Code	**Geo.616**
Subjects	**Basin Analysis (1 Cr), Engineering Geology (1 Cr.)**
Credits	**2**
Teaching hours	**90 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Practical**

Part A. Basin Analysis (1 Cr., 45 hours)

Lab 1: Drawing and describing a Wilson cycle. Drawing models of sedimentary basin formative mechanisms.

Lab 2: Drawing models of Rift Basins, Continental Margin and Slope Basins, Intracratonic basins.

Lab 3: Drawing models of Deep Sea Trenches, Forearc and Backarc Basins; Remnant Ocean and Foreland Basins; Pull-apart Basins.

Lab 4 : Constructing graphic and petrophysical logs from subsurface data, and correlation and interpretation.

Lab 5: Litho- and instrumental logs in interpretation of evolution of basin.

Lab 6: Facies analysis and interpretation of depositional models.

Lab 7: Lithofacies mapping and interpretation of basin.

Lab 8: Analysis of clastic petrofacies data in interpreting detrital modes, provenance, and Himalayan Unroofing history.

Textbooks and References:

1. Miall, A.D. (1984). Principles of Sedimentary Basin Analysis. Third Edition,
1. Springer Verlag, 616p.
2. Einsele, G (1992). Sedimentary Basins, Springer Verlag, 628p.
3. Allen, P. A. and Allen, J. R. (1990). Basin Analysis: Principles and Applications.
4. Blackwell Scientific Publications, London, 451p.
5. Tamrakar N. K. (2011). Practical Sedimentology, Bhrikuti Academic Publication,
6. Kathmandu, 232p.
7. 5. Nichols, G. (2009). Sedimentology and Stratigraphy. 2nd edition. Wiley-Blackwell, 418p.

Part B. Engineering Geology (1 Cr., 45 hours)

Lab 1: To Classify soil in Unified soil classification system.

Lab 2: To determine the unit weight of rock and soil specimens.

Lab 3: To determine tensile strength, point-load index, and classify strength of the rocks.

Lab 4: To determine uniaxial compressive strength, young's modulus and Poisson's ratio of rock.

Lab 5: To log drilled cores and determine RQD from core logs

Lab 6: To determine the weighted joint density.

Lab 7: To estimate rock mass quality Q, basic rock mass rating (RMR) and determine the correction technique, to design support system and span in tunnel

Lab 8: Site investigation problem for bridge site selection from given maps.
Lab 9: Site investigation problem for road site selection from given maps.
Lab 10: Site investigation problem for dam site selection from given maps.
Lab 11: Prepare engineering geological map of a landslide.

Textbooks and References:

1. Bell, F. G. (1980). Engineering Geology and Geotechniques, John Wiley and Sons, New York.
2. Bell F. G. (1982). Fundamentals of Engineering Geology, Aditya Books Pvt. Ltd., New Delhi, 648p. Beavis F. C. (1985). Engineering Geology, John Wiley and Sons, New York.
3. Price, D. G., 2009. Engineering Geology: Principles and Practice. Springer, 450p.
4. Krynine, D. P. and Judd W. R. (1957). Principles of Engineering Geology and Geotechniques, John Wiley and Sons, New York .
5. Legget K. F. and Hatheway (1988). Geology and Engineering, John Wiley and Sons New York.
6. Hock, E. and Bray J. (1977): Rock Slope Engineering, Institute of Mining and Metallurgy, London, 358p
7. Hoek, E., Kaiser, P. K. and Bawden, W. F. (2005). Support of Underground Excavations in Hard Rock. A. A. Balkema/Rotterdam/Brookfield, 225p.

Geo.617: Field Work (Applied Geology)

Semester	**III**
Course Title	**Field Work (Applied Geology)**
Course Code	**Geo.617**
Credits	**4**
Teaching hours	**28 days (280 hrs. of teaching per teacher)**
Full Marks	**100**
Pass Marks	**50**
Nature of the course	**Practical**

Course description: Fieldwork is carried out to provide the field knowledge on various branches of applied geology.
General objective: To give the knowledge, techniques and skill of field study in various disciplines of applied geology.
Specific objective: To provide the students with the techniques of

-Engineering geological study for
-Tunnelling and hydropower development,
-Road alignment fixing
-Landslide investigation
-Foundation design for building and bridges
-Environmental Sedimentological Study for
-River pattern and dynamics, and
-Sediment erosion, transport and yield
-Hydrogeological study.
-Mineral resource mapping, prospecting and exploration.

Location: The fieldwork will be carried out in the Kali Gandaki valley in the Parbat, Myagdi and Mustang Districts, Tanahu, Lamjung, Chitwan, Makawanpur, Kaverplanchowk and Sindhupalchok districts. The location may vary depending upon the criteria set by the Department.

Course Contents:

*1. Field work along the Kali Gandaki valley***:** 8 days fieldwork will be carried out along the Kali Gandaki valley from Beni to Muktinath. Student will study the MCT Zone, Higher Himalaya and Tethys Himalayan rocks. Students will study the metamorphic tectonites of the MCT zone and Higher Himalaya, inverted metamorphism, fossil contents in the Tethys Himalaya. They will also study various landforms (fluvial terraces, moraines etc.), engineering geological condition, geohazard and mineral resources in the region.

2. Engineering geological study: Students will learn engineering geological mapping, field testing of soils and rocks, methods of collection of geomorphological, hydrological and geotechnical data, preparation of engineering geological maps, engineering sedimentological data collection, stream profiling, stream cross-sectioning, river pattern and sediment transport analysis. Construction material survey and testing, seismic hazard analysis, recommendation for the boreholes and geophysical survey lines etc.

*3. Mineral prospecting and exploration***:** Students will learn methods of prospecting and exploration of mineral deposits, preparation of mineral deposit map, estimation of reserve and evaluation of the reserve, mine planning etc.
4. Hydrogeological study: Students will learn to prepare hydrogeological map, pumping test, water quality test, exploration of groundwater.

Field report: Students shall submit field report including all field and laboratory data in a given format and make formal presentation as part of the examination.

Textbook:

1. Thrope, R. S. and Brown, G. C. (1995). The Field Description of Igneous Rocks, John Wiley & Sons, 154 p.
2. Barnes, J. W. (1981). Basic Geological Mapping, Geological Society of London Handbook Series, No. 1 Open University Press.
3. Tucker, M. (1982). The Field Description of Sedimentation Rocks, Geological Society of London Handbook Series, No. 1 Open University Press.
4. Fry, N. (1984). The Field Description of Metamorphic Rocks, Geological Society of London Handbook Series, No. 3 Open University Press.
5. McClay, K. R. (1987): The Mapping of Geological Structures, John Wiley & Sons Inc., 161 p
6. Paudel, L. P. (2012) Handbook of Field Geology, Geo-Science Innovations (P) Ltd., 134p.
7. Tamrakar, N. K. (2013) Handbook of Field Geology with reference to the Siwaliks. Central Department of Geology, 162p.

References:

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

Geo.621: Groundwater Modeling

Semester	**III**
Course Title	**Groundwater Modeling**
Course Code	**Geo.621**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

Course description: This course deals with fundamentals of groundwater transport process and modeling.

General Objectives: Introducing flow and trnasport processes in groundwater , their mathematical representations and numerical modeling of various groundwater flows and tranport processes in porous and fracture media.

Course Contents:

Title	Details	Hrs.
Fundamentals	Introduction to types of équations, Geological processes and their mathematical représentations, Geological processes in fracture and porous media, Analytical Numerical solutions of geological processes in porous and fracture media.	4
Groundwater flow and transport	Flow in saturated and unsaturated zone, Flow in karstified aquifer systems, Flow and transport.	6
Groundwater Flow modeling	Introduction, Mathematical model of groundwater flow, Sources and Sinks, Boundary conditions, Forward modelling, finite-difference schemes and finite element schemes.	4
Groundwater flow modeling	Model calibration, model run, model validation, Flow in fracture media and their mathematical model.	4
Groundwater transport processes and modeling	Introduction, Transport Equation, Computation of steady-state velocity fields, Basic concept of particle-tracking methods, Particles and solute concentrations, Advection, Dispersion, Hydrodynamic dispersion, Breakthrough curves, Mass budget , Impact of layering on solute, transport, . Non-conservative and multiphase transport processes and their modelling, Reactive transport processes, Microbial decay, Multiphase transport in groundwater, Mathematical representation of multiphase transport	12

Textbooks and References:

1. Anderson, M. P. and Woessner W. W. (1992). Applied groundwater modeling - Simulation of flow and advective transport, Academic Press.
2. Bear, J. and Verruijt, A. (1985). Modeling groundwater flow and pollution, D. Reidel Publishing Comp..
3. Remson, I., Hornberger, G. M. and Molz, F. J. (1971). Numerical methods in subsurface hydrology, Wiley-Interscience.
4. Strack, O. D. L. (1988). Groundwater mechanics, Prentice-Hall.
5. Wang H. F. and Anderson, M. P. (1982). Introduction to groundwater modeling: Finite difference and finite element methods, W. H. Freeman.
6. Yakowitz, S. and Szidarovszky, F. (1989). An introduction to numerical computations, Macmillan, 2nd ed..
7. Chiang, W. H. and Kinzelbach, W. (2001). 3D-groundwater modeling with PMWIN, Springer.
8. Domenico, P. A. and Schwartz, F. W. (1990). Physical and chemical hydrogeology, John Wiley & Sons.
9. Istok J. (1989). Groundwater modeling by the finite element method, American Geophysical Union, Water Resources Monograph 13.
10. Sun, N. Z. (1995). Mathematical modeling of groundwater pollution, Springer.
11. Zheng, C. (1990). MT3D – A modular three-dimensional transport model for simulation of advection, dispersion, and chemical reaction of contaminants in groundwater systems, S. S. Papadopoulos & Associates, Waterloo.
12. Zheng, C. and Bennett, G. D. (1995). Applied contaminant transport modeling – Theory and prac-tice, Van Nostrand Reinhold.

Geo.622: Groundwater Basin Management

Semester	**III**
Course Title	**Groundwater Basin Management**
Course Code	**Geo.622**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

Course Description: This course provides the students with the concepts of groundwater basin/watershed management

General Objective: The course is designed to provide students with a holistic and integrated outlook in the management of groundwater basin. Students will gain a mountain ecosystems perspective on the numerous aspects of basin/watershed management for sustainable and environmentally compatible development, including fundamental ideas of basin, transfer of fluxes, watershed degradation , watershed analysis, and preparation of management plan.

Specific Objective: To provide the students with in-depth knowledge and practical skills on basin/watershed management:

- provide a basic concept of management principles in watershed
- analyze the river basin condition
- understand the management process and practice

Main Topic	Contents	Teaching hr
Introduction	Definition of drainage basin, sub-basin, watershed, sub-watershed; drainage basin development and morphology; river basin and groundwater basin; Major river basins of Nepal; Concept and importance of integrated basin/watershed management	2
Basin characteristics	Different characteristics of basin/watershed: Characteristics of snow-fed/permafrost region, rainfall/base-flow contributed river basin and karst aquifer; Geological control of watershed formation, development, and modification; morphometric parameters; analysis of watershed resources	4
Environmental Isotope and groundwater basin	Environmental isotopes in hydrogeology, use of environmental isotopes on identifying groundwater basin boundary, use of environmental isotope in recharge-discharge analysis	4
Basin/watershed degradation	Theories on watershed degradation, linkage between land use, soil and water, watershed monitoring and research,	2

Groundwater management	Groundwater management in sedimentary, metamorphic and igneous terrain. Surface water/groundwater interaction hydrological basin and between hydrogeological basins. Water balance in groundwater basin. Karst groundwater management, Karst groundwater contamination; Tracer test; water management in the karst.	6
Basin/Watershed management	Definition and concept of basin/watershed management; Advantages; components and approaches of watershed management; preparation of watershed management plan; groundwater basin plan; monitoring and evaluation tools and techniques; Logical framework	8
Basin/watershed management practices in Nepal	Trend and present practice of basin/watershed management in Nepal; policies and laws; responsible organizations	4

Textbooks

1. Gregersen, H. M, Foliott, P. F. and Brooks, K. N. (2007). Integrated watershed management: connecting people to their land and water. CAB International, 201p.
2. Clark, D. and Fritz, P. (1997). Environmental Isotopes in hydrogeology. CRC Press LLC, USA, 312 p.

References

1. Ritter, D. F, Kochel, R. C., and Miller, J. R. (2006). Process Geomorphology, Boston: McGraw-Hill.
2. Todd, D. K., Mays, W. M. (2005). Groundwater Hydrology. John Wiley & Sons, New York, 636 p.
3. Domenico, P. A. and Schwartz, F. W. (1990). Physical and Chemical Hydrogeology.- J. Wiley & Sons, Chichester.
4. UNESCO (2010). Sustainability of the Karst environment - Dinarik Karst and other Karst regions. Proceedings of international interdisciplinary scientific conference-2009. International Hydrological Program, IHP-VII/2010/GW-2, 185p.
5. Driscoll, F. (1986). Groundwater and Wells, St. Paul: Johnson Division
6. FAO Bulletins: Integrated watershed management.
7. Participatory Integrated watershed management
8. Soil and water conservation practices.
9. Publications from ICIMOD.
10. Journal publications

Geo.623: Hydrogeological Investigation

Semester	**III**
Course Title	**Hydrogeological Investigation**
Course Code	**Geo.623**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

Course Description: Increasing water demand for drinking, irrigation and industrial purpose does create pressure to the state to supply water in desirable quantity and quality. For this, the systematic and organized groundwater investigation in the various terrains might assure the water supply in desirable quantity. Groundwater investigation in hills, narrow valleys and mountains would be more crucial than it is in the huge alluvial plain like Indo-gangatic alluvium. More sophisticated groundwater investigation techniques would be needed to investigate its likely potential. There are three major areas to investigate hydrogeology.

General Objectives: The main objective of the proposed course is to create a comprehensive understanding of Hydrogeological Investigation Techniques in theoritical and practical basis.

Specific Objectives: The specific objective of the course is to enhance knowledge on,

-Surface and subsurface groundwater investigation techniques (well and spring inventory, surface geophysics, borehole geophysics, groundwater flow identification by tracer and other method)

-Laboratory investigation of hydrogeological parameters (such as airial photo and remote sensing data interpretation, permeability test, porosity determintion, fracture analysis, groundwater tracers, secondary porosity determination etc.).

Course Contents

Title	Content	Teaching hours
Hydrogeology and its relevance to various applications	Introduction on Hydrogeological investigation in groundwater exploration, land use planning	1
Surface investigation of Hydrogeological parameters.	Geological and Geomorphological investigation, use of aerial photo and satellite imageries. Investigation techniques in hard rock and soft sediments, drainage pattern, Karst aquifer: conduit and springs, recharge, precipitation response analysis. Sediments: homogeinity and heterogeinity,	10

	porosity and permeability of aquifer. Well Inventory, well hydrographs and stream hydrographs, groundwater chemistry.	
Surface and borehole Geophysical methods	Surface geoelectrical method: Evaluate porosity and permeability of the aquifer. Shallow seismic refraction method: application for hydrogeological investigation; GPR and Electromagnetic methods used in hydrogeological investigation and in assessing groundwater pollution. Borehole Geophysical logging in water wells.	10
Precipitation and groundwater recharge	Rainfall hydrographs separation, recharge estimation methods, water budgets	4
Hydrogeologial evaluation of the terrain	Integrated hydrogeological maps based on surface and sub-surface data (parameter incorporating, geology, lineament analysis, water table, piezometric head, transmissivity, porosity, permeability, lithologs, discharge, geophysical results, hydraulic system, water chemistry etc.)	5

Text Books and References:

1. Hudak, P. F. (2004). Principle of Hydrogeology. Third Edition, CRC Press LLC, 248 p.
2. Fetter, C. W. (2001). Applied Hydrogeology. Fourth Edi\tion, Pearson Education Limited, UK.
3. Weight, W. D. (2008). Hydrogeology-Field Manual. Second edition, McGraw-Hill Professional Publishing.
4. Todd, D. K and Mays, L. W. (2004). Groundwater Hydrology. Third Edition, Wiley. ISBN 978-0471059370.
5. USGS webpage.
6. Environmental Protection Agency, UK webpage.

Geo 624: Mountain Hydrogeology

Semester	**III**
Course Title	**Mountain Hydrogeology**
Course Code	**Geo.624**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

Course Description: This course provides the students with the concepts of mountain hydrogeology.
General Objective: To provide in-depth understanding of mountain hydrogeology covering both hard rock and unconsolidated aquifers.
Specific Objective: To provide the students with in-depth knowledge and practical skills on mountain hydrogeology, specifically:

- Fundamental concepts on hydrogeological setups in the mountainous region.
- Geomorphic evaluation and fracture mapping with respect to hard rock aquifer
- Assessment of recharge.
- Delineation of groundwater potential areas.

Course content:

Main Topic	Contents	Hrs.
Fundamental Concepts	Multidisciplinary integrated approach to study the hydrogeological mountain system; Regional geology and geomorphology; regional climate	4
Hydrogeological Information for mountainous region	Hydrogeological inventory, hydropedology; hydromorphology; defining hydrogeological units, isotope hydrology and identification of aquifer recharge area; Developing conceptual model on mountain hdyrogeology	6
Superficial deposits	Significance of superficial deposits, interaction between superficial granular aquifer and bedrock aquifer, pollution transport	2
Geomorphic evaluation	Geomorphic mapping of the terrain (aerial photograph/ satellite image/field mapping); groundwater occurrence in different physiographic regions	2
Fracture mapping	Concept of fracture mapping; mapping through satellite image, aerial photo, maps and direct field measurement; presentation of fracture data; common fracture pattern; surface geophysical methods Likely to be of use in locating zones of intense fracturing at different terrain condition; Stress and fracture characteristics in relation to permeability of hard rock.	4
Well drilling in bedrock	Identification of drilling site, method of drilling in hard rock; drilling depth; borehole orientation	2
Water quality of	Vulnerability and source protection at recharge area as well as at	3

mountain aquifer	the discharge area; pollution related parameters; groundwater contamination in hard rock; Risk Reduction and Disaster prevention, Water management and strategy	
Groundwater potential mapping	different parameters used for delineating groundwater recharge zones and groundwater potential zones; methods used to delineate recharge zone and potential zone	4
Exploiting mountain aquifer: Nepalese case	Importance of mountain aquifer; water availability (like spring/seepage) and livelihood; present practice of using mountain aquifer; issues related to changed availability through springs; way forward towards sustainable exploitation of groundwater in mountainous regions.	3

Textbooks:

1. Richard W. H. (2010). Estimating Groundwater Recharge. Cambridge University Press.
2. Banks, D. and Robins, N. (2002). An introduction to Groundwater in Crystalline bedrock. Norges geologiske undersøkelse, 64pp.

References:

1. Marques, J. E., Marques, J. M., Chaminé, H. I., Carreira, P. M., Fonseca, P. E., Santos F. A. M., Moura, R., Samper, J., Pisani, B., Teixeira, J., Carvalho, J. M., Rocha, F., Borges F. S. (2013). Conceptualizing a mountain hydrogeologic system by using an integrated groundwater assessment (Serra da Estrela, Central Portugal): a review, Geosciences Journal, Vol. 17, No. 3, p. 371 − 386, DOI 10.1007/s12303-013-0019-x.
2. Local water harvesting in mountain areas. ICIMOD News Letter, no. 36, 2000.
3. Water and mountains. ICIMOD Newsletter, no. 42, 2003.
4. Poudel D and Duex TW (2017). Vanishing Springs in Nepalese Mountains: Assessment of Water Sources, Farmers' Perceptions, and Climate Change Adaptation. Mountain Research and Development Vol 37, No 1 pp. 35–46. DOI: http://dx.doi.org/10.1659/MRD-JOURNAL-D-16-00039.1.
5. Journal articles (like Journal of hydrogeology, Journal of hydrogeology etc.
6. Otto, J. C. and Smith, M. J. (2013). Geomorphological mapping. In Geomorphological Techniques (Chap 2, Sec 6) ISSN 2047-0371.
7. José Teixeira , Helder I. Chaminé , José Martins Carvalho , Augusto Pérez-
8. Alberti & Fernando Rocha (2013). Hydrogeomorphological mapping as a tool in groundwater exploration, Journal of Maps, vol. 9, no. 2, pp. 263-273, DOI: 10.1080/17445647.2013.776506.

Geo.625: Practical of Geo.621 and Geo.622

Semester	**III**
Course Title	**Practical of Geo.621 and Geo.622**
Course Code	**Geo.625**
Subjects	**Groundwater Modeling (1Cr.), Groundwater Basin Management (1 Cr.)**
Credits	**2**
Teaching hours	**90 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Practical**

Part A: Groundwater Modeling

Lab 1: Solutions of groundwater flow and transport equations in porous and fracture media.
Lab 2: Forming conceptual groundwater models from various scenarios.
Lab 3: Numerical modeling of groundwater flow and transport problems.
Lab 4: Use of softwares (MODFLOW, MATLAB, R programming, GIS) for modeling of groundwater flow and transport processes.
Lab 5: Groundwater flow and transport modeling in Karstified aquifer systems

Part B: Groundwater Basin Management

Lab 1: Geological, hydrological and morphometric analysis of river basins and groundwater basins.
Lab 2: Delineate the areas importance from groundwater and surface water; potential areas for groundwater recharge and discharge
Lab 3: Calculation of exchange of water fluxes between groundwater basins and river basins.
Lab 4: Delineate watershed characteristics; identify various components within the watershed; assess land use condition; settlement distribution; socio-economic condition
Lab 5: Identify various issues within the watershed (geological; hydrological, hydrogeological, agriculture, forest, infrastructure, socio-economic etc.)
Lab 6: Prepare watershed management plan including groundwater resources management; present the plan in logical framework.
Lab 7: Case studies of well-studied groundwater basins.

Geo.626: Practical of Geo.623 and Geo.624

Semester	**III**
Course Title	**Practical of Geo.623 and Geo.624**
Course Code	**Geo.626**
Subjects	**Hydrogeological investigation (1Cr.), Mountain Hydrogeology (1 Cr.)**
Credits	**2**
Teaching hours	**90 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Practical**

Part A: Hydrogeological investigation (1 Cr.)

Lab 1: Geological analysis: Use bedding, joints and fracture system data of particular terrain to investigate groundwater flow direction and estimate secondary porosity.
Lab 2: Permeability Test: Constant head permeameter test in the laboratory with calculations.
Lab 3: Porosity Test: Rock and sediments.
Lab 4: Rainfall hydrograph separation: Different methods used in hydrograph separation.
Lab 5: Rainfall hydrograph separation; Different methods used in hydrograph separation.
Lab 6: Geophysical exploration: Provide geophysical data and make interpretation (Resistivity and seismics) with respective to aquifer delineation and characterization.
Lab 7: GIS modeling: Incorporate data of relevant aqifer parameters and aquifer material, as well as rainfall and other relevant parameter to generate groundwater potential map from well data..
Lab 8: Hydrogeological Map: Incorporate all available above information and prepare comprehensive hydrogeological map of the terrain.

Part B: Mountain Hydrogeology (1 Cr., 45 hrs.)

Lab 1: Delineate different types of aquifers in the given watershed of mountainous region
Lab 2: Preparation of geomorphological map from aerial photo/satellite image or topographic maps from groundwater perspective.
Lab 3: Fracture/lineament mapping from aerial photo/satellite image.
Lab 4: Interpret hydrogeology of the given area through the given spring location and geological map.
Lab 5: Identify recharge area and estimate groundwater recharge in mountain aquifers.
Lab 6: Interpretation of groundwater quality in the given area with respect to geology and aquifer types.
Lab 7: Vulnerability assessment and protection at recharge area as well as at the discharge area.
Lab 8: Preparation of various thematic layers in GIS for hydrogeomorphological map.
Lab 9: Preparation of groundwater potential map in the mountainous region using GIS through various methods.

Geo.627: Field Work (Hydrogeology)

Semester	**III**
Course Title	**Field Work (Hydrogeology)**
Course Code	**Geo.627**
Credits	**4**
Teaching hours	**28 days (280 hrs. of teaching per teacher)**
Full Marks	**100**
Pass Marks	**50**
Nature of the course	**Practical**

Course description: Fieldwork is carried out to provide the field knowledge on various methods of hydrogeological investigations.
General objective: To give the knowledge, techniques and skill of field study in various disciplines of hydrogeology.
Specific objective: To provide the students with the techniques of
-Hydrogeological maps.
-Pumping test and water quality test.
-Exploration of groundwater etc.

Location: The fieldwork will be carried out in the Kali Gandaki valley in the Parbat, Myagdi and Mustang Districts, Tanahu, Lamjung, Chitwan, Makawanpur, Kaverplanchowk and Sindhupalchok districts. The location may vary depending upon the criteria set by the Department.

Course Contents:

*1. Field work along the Kali Gandaki valley***:** 8 days field work will be carried out along the Kali Gandaki valley from Beni to Muktinath. Student will study the MCT Zone, Higher Himalaya and Tethys Himalayan rocks. Students will study the metamorphic tectonites of the MCT zone and Higher Himalaya, inverted metamorphism, fossil contents in the Tethys Himalaya. They will also study various landforms (fluvial terraces, moraines etc.), engineering geological condition, geohazrd and mineral resources in the region.

2. Hydrogeological study: Students will learn to prepare hydrogeological map in plain and mountainous terranins, carry out pumping test, carry out water quality test and exploration of groundwater. Students will also learn field methods of groundwater basin investigation and management, sampling and analysis of groundwater,

Field report: Students will submit field report including all field and laboratory data in a given format and make formal presentation as part of the examination.

Textbooks:

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

10. Tucker, M. (1982). The Field Description of Sedimentation Rocks,Geological Society of London Handbook Series, No. 1 Open University Press.
11. Fry, N. (1984). The Field Description of Metamorphic Rocks,Geological Society of London Handbook Series, No. 3 Open University Press.
12. McClay, K. R. (1987). The Mapping of Geological Structures,John Wiley & Sons Inc., 161 p
13. Paudel, L. P. (2012). Handbook of Field Geology, Geo-Science Innovations (P) Ltd., 134p.
14. Tamrakar, N. K. (2013). Handbook of Field Geology with reference to the Siwaliks. Central Department of Geology, 162p.
15. Todd, D. K., Mays, W. M. (2005). Groundwater Hydrology. John Wiley & Sons, NewYork, 636 p.
16. Domenico, P. A. and F. W. Schwartz (1990). Physical and Chemical Hydrogeology.- J.Wiley& Sons, Chichester.
17. Freeze R. A. and Cherry J. A. (1979). Groundwater, Prentice Hall.
18. Fetter, C. W., (1994). Applied hydrogeology. McMillian, new York.
19. Raghunath, H. M. (2006). Ground Water, New Age International Private Limited, New Delhi.
20. M.6, Ground water irrigation Manual, (1990),Sir MacDonald and Partners.

References:

4. Gansser, A. (1964). Geology of the Himalayas, John Wiley & Sons Inc.
5. Journal of Nepal Geological Society (Various issues).
6. Bulletin of Department of Geology (Various issues).

Geo.631: Rock Engineering

Semester	**III**
Course Title	**Rock Engineering**
Course Code	**Geo.631**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

Course description: The course deals with fundamental principles of rock slope and related engineering applied in mineral exploration.

General objective: To provide in-depth knowledge and practical skills on rock slope engineering techniques applied to investigate rock slope related issues in mining activities.

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

-rock structures data
-rock slope failure analysis and management
-Laboratory equipment used in rock slope engineering
-data collection, analysis, and interpretation for stabilization and management of rock slope

Course Contents:

Title	Details	Teaching hr
The development of rock engineering:	Introduction, Principles of rock slope engineering, Slope features and dimensions, Rock slope design methods, Laboratory testing of rock, Analytical tools	2
Site investigation and geological data collection	Planning an investigation, site reconnaissance , geologic mapping, spacing, persistence and roughness measurements, probabilistic analysis of structural geology, diamond drilling	2
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 Tunneling Quality Index (Q), Using rock mass classification systems, GSI and NATM methods.	4
	Introduction, Shear strength of planar surfaces, Shear strength of rough surfaces, Barton's estimate of shear	4

Shear strength of discontinuities	strength, Field estimates of JRC, Field estimates of JCS, Influence of scale on JRC and JCS, Shear strength of filled discontinuities, Influence of water pressure, Instantaneous cohesion and friction	
Structurally controlled instability in tunnels	Introduction, Identification of potential wedges, Support to control wedge failure, Rock bolting wedges, Shotcrete support for wedges, Consideration of excavation sequence, Application of probability theory	3
Factor of safety and probability of failure:	Introduction, Sensitivity studies, An introduction to probability theory, Probability of failure, Probabilistic design methods, Load and Resistance Factor Design	2
Rock mass properties	Introduction**,** Generalised Hoek-Brown criterion**,** uniaxial compressive strength, Intact rock properties, Geological strength Index, Mohr-Coulomb parameters, Determination of σ min and max, Deformation modulus, Post-failure behavior**,** Reliability of rock mass strength estimates**,** Input parameters**,** Slope stability calculation**,** Tunnel stability calculations	2
In situ and induced stresses	Introduction, In situ stresses, The World Stress map, Developing a stress measuring programme, Analysis of induced stresses, Numerical methods of stress analysis, Boundary Element Method, Finite element and finite difference methods Distinct Element Method, Hybrid approaches, Two-dimensional and three-dimensional models: Examined3D, FLAC3D, Phase2, Examples of two-dimensional stress analysis, Large underground caverns	3
Practical examples of rock mass property estimates	Massive weak rock**,** Massive strong rock masses**,** weathering of rocks, Average quality rock mass**,** Poor quality rock mass at shallow depth**,** Poor quality rock mass under high stress**,** Slope stability considerations, tunneling in soft rocks, tunnels in swelling and squeezing rocks, cases of instability in tunnels, TBM excavation.	2

Rock mechanics in mining	Field and laboratory procedures for determining rock material properties, stress analysis for mine design, stability analysis of surface and underground mine excavations, risk assessment processes, legislative requirements for geomechanics in mining.	2
The ground control systems	Introduction to ground support elements in mining and tunneling, design and specification of ground control systems, shotcrete and surface support systems, quality control for ground control systems, risk assessment and risk management processes, development of ground control management plans, legislative requirements for ground control in mining.	2
Case studies	Stabilization of rock slopes, few case studies of underground excavations, tunnels and rockfall protection systems in Nepal, Mining applications	2

Text book

1. Hoek, E. (2007). Practical Rock Engineering, Published by Evert Hoek Consulting Engineer Inc. 3034 Edgemont Boulevard, P.O. Box 75516, North Vancouver, B.C. Canada. Available in https://www.rocscience.com/, 237p.
2. Duncan, C. , Wyllie and Chris, M. (2004). Rock Slope engineering, Spoon Press. 432p.

Reference book

1. Hencher, S. (2015). Applied Geotechnics-Practical Rock Mechanics. CRC Press, 378p.
2. Journal articles published in Journals and Bulletins of Nepal Geological Society.

Geo.632: Mine Surveying and Mine Development

Semester	**III**
Course Title	**Mine Surveying and Mine Development**
Course Code	**Geo.632**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

Course Description: This course offers the fundamental principles of mine surveying practices, instrumentations and mine development practices in surface and underground mines.
General Objective: To provide in-depth understanding of Mine Surveying practices and mine development concept and methodology
Specific Objective: To make the students able to

- To comprehend the mine surveying concepts
- To apprehend the various mine surveying method including surface and underground survey
- To understand the surveying instruments
- To get knowledge about surveying and geological mapping
- To acquire information about Cadastral Surveying & Land management
- To know general Engineering Survey practices
- To get knowledge for mine development

Course Contents:

Topic	Details	Hrs.
Introduction	Fundamental definitions and concepts – Principles of survey, units of measurements, scales, Linear and Measurements, map reading, map and plan, measurement errors, Units, Standardization and Conversion, Application of Surveying	3
Surveying methods	Chain surveying, Traverse Surveying, Leveling, Plain Table Surveying, Contouring and Topographic surveying, Tachometric surveying, Trigonometrical leveling, Underground mine surveys, Triangulation	4
Surveying Instruments	Essential components in a direction measuring instrument - magnetic compass, surveyor's compass, Brunton compass, Topographical surveying instruments: plane table & accessories, Level, Theodolites (analog and digital), total station, Accuracy and errors in Survey ranging instruments, distance measuring instruments: Surveyor's chain, measuring tape, Stadia measurement system, electronic distance meters, principle of direction measurements; direction	5

	elements: meridians, bearing and conversion; magnetic declination;	
Mapping	Mine Surveying and computer application in mining, map projection; map sheet numbering; generalization, relief representation; colour; digital cartography	4
Cadastral Surveying	Fundamentals of cadastral surveying and cadastral maps, Cadastral Data Acquisition, Cadastral Surveying in Nepal Essential components of survey management, technical standards and specifications	2
Engineering Survey	Survey Component in various engineering construction projects, route survey; area and volume; site survey, Types of estimates; methods/procedures of estimating	3
Mine Development	Definition of mining terminology in exploration and exploitation, Access to mineral deposits, selection of opening methods, Surface Mining development, Underground Mine Development: Shaft sinking, Tunneling, Inclines, Drifting and Raising, Mine Development tools, machineries and equipments,	8
Safety Consideration & Legal Provision	Safety consideration During surveying and errors in surveying Safety consideration in mine development, Legal Provision	1

Textbooks and References:

1. Deshmukh, D. J. (2010). Elements of Mining Technology (8th Edition), Vol. I, Denett & Company, 424p.
2. Deshmukh, D. J. (2016). Elements of Mining Technology (9th Edition), Vol. II, Denett & Company, 323p.
3. Deshmukh, D. J. (2016). Elements of Mining Technology (8th Edition), Vol. III, Denett & Company, 368p.
4. Peele, R. (1918). Mining Engineers Handbook, John Wiley & Sons, Inc . 2292p.
5. Punimia, B. C. (2005). Surveying, Laxmi Publications Pvt. Ltd.
6. Bannister, A. and Raymond, S. (1992). Surveying, Longman.

Geo.633: Drilling and Blasting

Semester	**III**
Course Title	**Drilling and Blasting**
Course Code	**Geo.633**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

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 mining excavation activities, and determines the safety, economic success, and viability of these operations.

Course Objectives: To deliver the students 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.

Course Objectives: To convey the students the information and knowledge of

- rock drilling and drill bits,
- commercial explosives and their usage,
- procurement, transport and economics of explosives usage,
- blasting, its mechanism and methods, and effects of blasting.

Course Contents:

Topics	Details	Hrs.
Drilling	Principles of rock drilling, drillability, drillability index, factors affecting the drillability	3
Introduction to Explosives	History of explosives, Theory of explosion, Chemical composition of explosives, Types of explosives used during blasting operation – Gelatine, Detonators (Delay detonators, electric & nonelectric detonators), Fuse wire & capes	5
Use of Explosives	Field of explosives usage, Blast design: Drilling for quarry and underground blasting, Surface blasting, quarry blasting, Underground excavation (Tunnel excavation, cavern excavation), Controlled blasting, Controlled demolition of structures, Emergency blasting (Removal of river blockade, road blockade etc)	12
Legal requirements for explosive handling	Licenses required for explosives handling, Procurement Procedures for explosives, Blasting License, Blaster (The person authorized to carry out blasting operation)	3

Safety procedures for explosives handling	Security arrangement during transportation and storage, Bunkers and its security, Security arrangement during usage of explosives	2
Economic of explosives Usage	Cost of explosives, Consumption of explosives under various blasting condition, Mechanical demolition versus blasting	5

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.

References:

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. R. and Mishra, B. (1998). Principles of Rock Drilling, Chapter 1 and 2 Oxford and IBH.

Geo.634: Mining Machinery and Transportation

Semester	**III**
Course Title	**Mining Machinery and Transportation**
Course Code	**Geo.634**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

Course Description: This course offers the fundamental principles of mining machineries and transportation equipments used in both opencast and underground mines.

General Objective: To provide in-depth understanding of Mining Machineries and Transportation practices.

Specific Objective: To make the students able to

- To understand the different mining machineries and equipments used in mines for excavation, transportation, ventilation etc.
- To apprehend the various mine transportation method including surface and underground mining.

Course Contents:

Topics	Details	Hrs.
Mining Machinery	Different kinds of machineries used in development, excavation, transportation, ventilation, water pumping etc.	4
Development and Excavation Equipments	Dozer, Excavators, Back-hoe, Tunnel Boring Machine, Dredgers Cranes, Loaders, etc.	10
Transportation Equipments	Dumpers, trippers, Ropeways, Conveyor belts, trams, skips, hoist, etc	8
Ventilation and Pumping	Different kind of Pumps, Fans, Compressors	8

Textbooks:

1. Deshmukh, D.J (1987). Elements of Mining Technology Vol. I, II & III Fifth Edition, Vidyasewa Prakasan. 431P
2. Pele, R., Church, J.A, Mining Engineer's Handbook, Third Edition 2442P

3. Introductory Mining Engineering, 2nd Edition, Howard L. Hartman, Jan M. Mutmansky , ISBN: 978-0-471-34851-1, 584 pages, July 2002.
4. Surface Mining by Prof. Dr. G. B. Misra, Dhanbad Publishers.

Reference Books:

1. Mining Engineers' Handbook by Robert Peele, John Wiley and Sons Inc., 1918.
2. SME, Mining Engineers Handbook, 3rd Edition, 2011 Publisher: Society for Mining, Metallurgy and Exploration, Colorado, United States.
3. Open Pit Mine Planning and Design, Volume 1 - Fundamentals by William Hustrulid et. al., 2013 published by Taylor & Francis Group, LLC.
4. Mining Methods - pwc.pdf-Adobe Reader, 2012 American School of Mines, Basics of Mining and Mineral Processing, by W Scott Dunbar, University of British Columbia.

Geo.635: Practical of Geo.631

Semester	**II**
Course Title	**Practical of Geo.631**
Course Code	**Geo.635**
Subjects	**Rock Engineering**
Credits	**2**
Teaching hours	**90 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Practical**

Course Contents:

Lab 1: Solving numerical problems related to rock slope engineering.
Lab 2: Determination of unit weight of rock specimens.
Lab 3: Determination of point-load index and classification of strength of the rocks.
Lab 4: Determination of uniaxial compressive strength of rock.
Lab 5: Determination of the young's modulus and Poisson's ratio of rock.
Lab 6: Logging of drilled cores and geophysical data, and determine RQD from core logs.
Lab 7: Determination of tensile strength of rocks.
Lab 8: Analysis of plane failure in rock slope.
Lab 9: Analysis of wedge failure in rock slope.
Lab 10: Analysis of toppling failure in rock slope.
Lab 11: Application of geological strength index in estimating rock mass strength.
Lab 12: Estimation of basic rock mass rating and determine the correction technique.
Lab 13: Estimation of slope mass rating and its use.
Lab 14: Determination of factor of safety of a potential failure with undulated discontinuities.
Lab 15: Estimation of rock mass quality Q.
Lab 16: Determination of the weighted joint density.
Lab 17: Design of support system and span in tunnel.
Lab 18: Evaluation of rock slope for earthquake-induced landslides.
Lab 19: Preparation of GIS-based rock hazard and susceptibility maps.
Lab 20: Performing rock fall simulation and design of rock fall protection system.
Lab 21: Identification of rock slope for active rock fall protection systems: wire mesh, draping and rock netting.
Lab 22: Determination of bearing capacity on rock slope.

Text book

3. Hoek, E. (2007). Practical Rock Engineering, Published by Evert Hoek Consulting Engineer Inc. 3034 Edgemont Boulevard, P.O. Box 75516, North Vancouver, B.C. Canada. Available in https://www.rocscience.com/, 237p.
4. Duncan, C. , Wyllie and Chris, M. (2004). Rock Slope engineering, Spoon Press. 432p.

Reference book

3. Hencher, S. (2015). Applied Geotechnics-Practical Rock Mechanics. CRC Press, 378p.
4. Journal articles published in Journals and Bulletins of Nepal Geological Society.

Geo.636: Practical of Geo.632

Semester	**III**
Course Title	**Practical of Geo.632**
Course Code	**Geo.636**
Subjects	**Mine Surveying and Mine Development**
Credits	**2**
Teaching hours	**90 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Practical**

Course Description: This course provides the fundamental principles of mine surveying practices, instrumentations and mine development practices in surface and underground mines.
General Objective: To provide in-depth understanding of Mine Surveying practices and mine development concept and methodology in practical way.
Specific Objective: To make the students able to

- To generalized the mine surveying concepts
- To understand the various mine surveying method including surface and underground survey
- To understand the surveying instruments
- Get knowledge about surveying and geological mapping and GIS
- Get information about Cadastral Surveying & Land management
- To know general Engineering Survey practices
- To get knowledge for mine development

Course Contents

Lab 1: Introduction: Units of measurements, scales, Linear and Measurements, map reading, map and plan, Units, Standardization and Conversion (9 hrs).
Lab 2: Surveying Practices and methodology: Chain surveying, Traverse Surveying, Leveling, Plain Table Surveying, Contouring and Topographic surveying, Tachometric surveying, Trigonometrical leveling, Underground mine surveys, Triangulation (21 hrs.).
Lab 3: Surveying Instruments: Demo - magnetic compass, surveyor's compass, Brunton compass, Compass, Topographical surveying instruments: plane table & accessories, Level, Theodolites (analog and digital), total station, ranging instruments, distance measuring instruments: Surveyor's chain, measuring tape, Stadia measurement system, electronic distance meters. (6 hrs)
Lab 4: Mapping and GIS : map sheet numbering; colour; digital cartography
GIS applications: data integration; spatial analysis; measurement; Data Acquisition, Processing & Analysis. (15 hrs.)

Lab 5: Cadastral Mapping: Cadastral surveying and cadastral maps, Cadastral Data Acquisition. (9hrs.)
Lab 6: Engineering Survey: Route survey; area and volume; site survey, Types of estimates; methods/procedures of estimating. (9 hrs.)

Lab 7: Access to mineral deposits, Surface Mining development, Underground Mine Development: Shaft sinking, Tunneling, Inclines, Drifting and Raising. (21 hrs.)

Textbooks and References:

1. Deshmukh, D. J. (2010). Elements of Mining Technology (8th Edition), Vol. I, Denett & Company, 424p.
2. Deshmukh, D. J. (2016). Elements of Mining Technology (9th Edition), Vol. II, Denett & Company, 323p.
3. Deshmukh, D. J. (2016). Elements of Mining Technology (8th Edition), Vol. III, Denett & Company, 368p.
4. Peele, R. (1918). Mining Engineers Handbook, John Wiley & Sons, Inc . 2292p.
5. Punimia, B. C. (2005). Surveying, Laxmi Publications Pvt. Ltd.
6. Bannister, A. and Raymond, S. (1992). Surveying, Longman.

Geo.637: Field Work (Mining Geology and Mineral Exploitation)

Semester	**III**
Course Title	**Field Work (Mining Geology and Mineral Exploitation)**
Course Code	**Geo.637**
Credits	**4**
Teaching hours	**28 days (280 hrs. of teaching per teacher)**
Full Marks	**100**
Pass Marks	**50**
Nature of the course	**Practical**

Course description: Fieldwork is carried out to provide the field knowledge on various methods of mining.
General objective: To give the knowledge, techniques and skill of field study in various disciplines of Mining Geology and Mineral Exploitation.
Specific objective:
-To deliver the students the techniques of
-Prospecting and exploration of minerals.
-Exploitation of minerals.
-Mineral processing etc.

Location: The fieldwork will be carried out in the Kali Gandaki valley in the Parbat, Myagdi and Mustang Districts, Tanahu, Lamjung, Chitwan, Makawanpur, Kaverplanchowk and Sindhupalchok districts. Field work will be carried out also in some established mining areas in Nepal and adjacent areas of India and Tibet. The location may vary depending upon the criteria set by the Department and available resources.

Course Contents:

*1. Field work along the Kali Gandaki valley***:** 8 days field work will be carried out along the Kali Gandaki valley from Beni to Muktinath. Student will study the MCT Zone, Higher Himalaya and Tethys Himalayan rocks. Students will study the metamorphic tectonites of the MCT zone and Higher Himalaya, inverted metamorphism, fossil contents in the Tethys Himalaya. They will also study various landforms (fluvial terraces, moraines etc.), engineering geological condition, geohazrd and mineral resources in the region.

2. Mineral Prospecting, Exploration, Mining and Mineral Processing Techniques: Students will learn methods of prospecting and exploration of metallic minerals, non-metallic minerals, gems and petroleum. They will learn to prepare mineral resource map of a region. They will also learn the methods mining and processing of minerals. They will learn techniques of mineral sampling and analysis.

Field report: Students will submit field report including all field and laboratory data in a given format and make formal presentation as part of the examination.

Textbook:

1. Thrope R. S. and Brown G. C. (1995): *The Field Description of Igneous Rocks,* John Wiley & Sons, 154 p.

2. Barnes J. W. (1981): *Basic Geological Mapping*, Geological Society of London Handbook Series, No. 1 Open University Press.
3. Tucker M. (1982): *The Field Description of Sedimentation Rocks*, Geological Society of London Handbook Series, No. 1 Open University Press.
4. Fry, N. (1984): *The Field Description of Metamorphic Rocks*, Geological Society of London Handbook Series, No. 3 Open University Press.
5. McClay K. R. (1987): *The Mapping of Geological Structures*, John Wiley & Sons Inc., 161 p
6. Paudel, L. P., 2012: Handbook of Field Geology, Geo-Science Innovations (P) Ltd., 134p.
7. Tamrakar, N. K., 2013: Handbook of Field Geology with reference to the Siwaliks. Central Department of Geology, 162p.
8. Mining Journals

Reference Books:

1. Gansser, A. (1964): *Geology of the Himalayas*, John Wiley & Sons Inc.
2. Journal and Bulletins of Nepal Geological Society/TU (Various issues).
3. Bulletin of Department of Geology (Various issues).
4. Annual Report of Department of Mines and Geology (Various issues)
5. Marjoribanks, R., (2010): Geological Methods in Mineral Exploration and Mining, Springer-Verlag Berlin Heidelberg, 238p.
6. Babu, S. K. and Sinha, D. K. (1988): Practical Manual of Exploration and Prospecting, CBS Publishers India, 167 p.
7. Kreiter, V. M. (2004): Geological Prospecting and Exploration, University Press of the Pacific, 384p.
8. Barrett W. M. et al. (2012): Introduction to mineral exploration, Blackwell Publication, 481p.

IV
SEMESTER
CURRICULUM

Geo.651: Techniques of Structural Analysis

Semester	**IV**
Course Title	**Techniques of Structural Analysis**
Course Code	**Geo.651**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

Course Description: The coursegives the necessary knowledge and skills of analysis and interpretation of geological structures.
General Objective: To give in-depth knowledge and understanding of structural analysis techniques.
Specific Objective: To provide the students with in-depth knowledge and practical skills of

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

Course Contents:

Title	Details	Hrs.
Introduction	Historical Background. Structural analysis, scope of structural analysis, limitations of structural analysis	2
	Definition and purpose, factors in structural analysis, geometric, kinematic and dynamic analysis	2
Geologic bodies	Definition, Scale of geologic bodies, Homogenous and heterogenous geologic bodies, Fabric of geologic bodies,	2
	Fabric domain, Penetrative and non-penetrative discontinues in geologic bodies, Fabric elements and fabric data,	2
	Isotropic and anisotropic fabrics, concept of tectonite, componental movement, types of tectonite, Fabric elements of tectonite	2
Microtectonics: Deformation mechanism	Introduction, cataclastic flow, pressure solution, intracrystalline deformation, recovery, recrystallisation (grain boundary migration recrystallisation, subgrain rotation recrystallisation, competing processes during deformation),	2
	Solid state diffusion creep, grain boundary sliding and super plasticity, grain boundary area reduction, static recrystallisation, deformation of some rock forming minerals (Introduction, Quartz, Calcite and Dolomite, Feldspar, Micas, Olivine, Orthopyroxene, Amphiboles),	2
	Deformation of polymineralic rocks (Introduction, Quartz-Feldspar aggregates, deformed ignimbrites), flow laws and deformation mechanics maps.	2

Microtectonics: Shear Zones	Introduction, brittle fault rocks (incohesive fault rocks, cohesive fault rocks, pseudotachylite), Mylonite (Introduction, characteristics fabric elements, mylonite classification, dynamic of mylonite development, mylonite and metamorphic conditions),	2
	Complex fault rocks, sense of shear (Introduction, displacement and deflection of markers, foliation curvature), microscopic shear sense indicators in mylonite (Introduction, foliation orientation, oblique foliations, shear band cleavage, mantled porphyroblast, development of mantle porphyroblast, mica fish, quarter structures, lattice-preferred orientation,	2
	Vergence of asymmetric fold sections, potential shear sense markers), shear sense indicators in brittle regime (Introduction, incohesive brittle fault rocks, cohesive brittle fault rocks, pseudotachylite)	2
Stress strain relationship	Geological significance of strain ellipse, progressive deformation,	2
	Relationship of finite and infinitesimal strain, Coordinate transformation equations,	2
	Relationship between stress and strain	2
Techniques of structural data collection in the field and laboratory and their interpretation		2

Textbooks:

1. Ramsay, J. G. (1967): *Folding and Fracturing of Rocks,* McGraw Hill Inc., *568* p.
2. Turner, F. and Weiss, L. E. (1963):*Structural Analysis of Metamorphic Tectonites,* McGraw Hill Book Company, *545* p.
3. Passchier, C. W. and Trouw R. A. J. (2003): *Micro-tectonics,* Springer, 253 p.
4. Ramsay, J. G. and Huber, M. I (1983): *The Techniques of Modern Structural Geology, Volume 1: Strain Analysis,* Academic Press, 307 p.
5. Ramsay, J. G. and Huber, M. I (1987): *The Techniques of Modern Structural Geology, Volume 2: Folds and Fractures,* Academic Press, 309-700 p.

References:

1. Bayly, B. (1991): *Mechanics in Structural Geology*, Springer-Verlag, 253 p
2. McClay, K. R. (1987): The Mapping of Geological Structures, John Wiley & Sons Inc., 161 p.
3. Ragan D. M. (1985): *Structural Geology, An Introduction to Geometrical Techniques,*3rd edition,John Wiley & Sons Inc., 393 p.
4. Means W. D. (1985): *Stress and Strain Basic concepts of continuum mechanics for geologists*, Springer-VerlagNew York, 339 p.

Geo.652: Tectonic Geomorphology and Neo-tectonics

Semester	**IV**
Course Title	**Applied Geomorphology and Neo-tectonics**
Course Code	**Geo.652**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

Part A: Applied Geomorphology (1 cr., 15 hrs.)

Course description:

The course on applied geomorphology provides the students with the understanding of the tectonic features earth's surface in relation to the external and internal processes. It also studies the processes responsible for the change of the earth's landscape.

General objectives:

To give in-depth knowledge and understanding of the earth's landscape especially the tectonic process that is responsible for the shaping of the earth's surface.

Course contents:

Title	Details	Hrs.
Introduction to tectonic geomorphology	Introduction: Energetics, Active tectonics and models of landscape development, The new world, Some modern controversies.	2
Geomorphic markers	Planar geomorphic markers, Linear geomorphic markers, Commonly encountered problems with markers.	4
Establishing timing in the landscape: dating methods	Relative dating methods, Absolute dating methods.	2
Stress, Faults, and folds	The earthquake cycle; Asperities, barriers, and characteristic Earthquakes; Displacement variations along a fault, fault growth, and fault segmentation; Geomorphic expression of faults; Folds.	4
Short-term deformation: geodesy	Near-field techniques; Far-field techniques.	3
Rates of erosion and uplift	Rates of erosion and denudation; Rates of uplift.	3
Holocene deformation and landscape responses	Base level; Theoretical perspective on fluvial erosion and river profiles; Knickpoints; Channel patterns and characteristics.	4

Deformation and geomorphology at intermediate time scales	Unresolved problems at intermediate time scales; Calibrating rates of deformation; Landscape responses at intermediate time scales; From landscapes to faults; Transient landscapes; Fault behavior.	4
Tectonic geomorphology at late Cenozoic time scales	Hot topics and unresolved questions; Range fronts, basins, and normal faults; Contractions, folds, and drainage networks; Steady state and pre-steady state; Climate and tectonics; Dynamic topography; Shaping landscapes during orogenic growth.	4

Textbooks:

1. Douglas W. Burbank and Robert S. Anderson, Tectonic Geomorphology, 2nd Edition (2012), 474 p.

References:

1. William B. Bull, Tectonic Geomorphology of Mountains, 1st Edition (2007), 329 p.
2. Andrew Goudie et al. Geomorphological Techniques, 2nd Edition (1990), 710 p.

Part B: Neotectonics (1 cr., 15 hrs.)

Course Description: This course provides the fundamental principles of Neotectonics such as Paleoseismology, Morphotectonics, active faults, Historical earthquakes of Nepal, Field technique to quantify the seismic landforms.

General Objective: To provide in-depth understanding of earthquake processes and associated landforms.

Specific Objective: To make students able to understand the

- Recent advances in Neotectonics
- Active Fault in Nepal Himalaya
- Field technique in Paleoseismology
- Historical Earthquakes in this region.

Course Contents:

Title	Details	Hrs.
History	Historical Earthquakes of Nepal	1
Plate tectonics and seismicity	Plate tectonics and Global Seismicity, GPS monitoring for Crustal deformation and Earthquake.	2
Morhotectonics	Fluvial Terraces and Morphotectonics,	1
Study of prehistoric and historic	Identification of Prehistoric and historic Earthquakes based on Primary and Secondary signatures preserved in	5

earthquakes	landforms and sedimentary succession. Active faults and identification of associated landforms. Identification and characterization of active faults and associated landforms in aerial photographs/satellite Imagery.	
Paleoseismology	Paleoseismological studies in Himalayan region. Field technique in Paleoseismology. Quantification of active fault scarp by precise mapping, identification of past (prehistoric) earthquake by trenching, mapping of deformed sedimentary succession by faulting, estimation of net displacement during single event, slip rate, magnitude of historic earthquake, recurrence interval, and recent development in prediction of earthquake.	5
Study of Secondary effects of seismic shaking	Identification and mapping of secondary effects due to strong seismic shaking – identification of paleo-liquefaction features; Dating techniques; Correlation of paleoseismic data with existing geodetic and geophysical data; Delineation of seismogenic faults. Understanding land-level change caused by major earthquakes, decoupling the role of climate and tectonics.	4

Textbooks:

1. Yeats, R. s., Sieh, K. E. and Allen, C. R. (1997). Geology of Earthquakes. Oxford University Press.

References:

1. PJames Mccaplin 1996, Paleoseismology Treatise on Geophysics Vol. 6.
2. Nabbe Sal ko Mahabhujampa : Brahma Samser Rana.

Geo.653: Global Tectonics and Seismology

Semester	**IV**
Course Title	**Global Tectonics and Seismology**
Course Code	**Geo.653**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

Part A: Global Tectonics (1 Cr., 15 hrs.)

Course Description: Global Tectonics, the branch of geology, deals with the large-scale Earth structures and their deformation

General Objective: To give in-depth knowledge and understanding of the structure of the earth and its formation, particularly in relation to continental tectonics and mantle convection.

Specific Objective: The course provides in-depth knowledge of large scale tectonics, thin skin tectonics and micro-tectonics.

Course content:

Title	Details	Hrs.
Historical perspective	Continental drift, sea floor spreading and the birth of plate tectonics, geosynclinals theory and the impact of plate tectonics	1
Continental drift	Continental drift: Continental reconstructions- Euler's theorem, geometric reconstructions of continents;geologic evidence for continental drift, paleoclimatology, paleontologic evidence for continental drift; paleomagnetism: rock magnetism, natural remanent magnetization, past and present geomagnetic field, apparent polar wander curves	1
Sea floor spreading and transform faults	Sea floor spreading: marine magnetic anomalies, geomagnetic reversals, seafloor spreading, Vine-Matthews hypothesis, magnetostratigraphy, dating the ocean floor; transform faults:ridge-ridge transform faults, ridge jumps and transform fault offsets	1
The framework of plate tectonics	Plates and plate margins, distribution of earthquakes, relative plate motions, absolute plate motions, hotspots, true polar wander, cretaceous superplume, direct measurement of relative plate motions, finite plate motions, stability of triple junctions, present day triple junctions.	2
Continental rifts and rifted margins	General characteristics of narrow rifts, general characteristics of wide rifts; volcanic activity: large igneous provinces, mantle upwelling beneath rifts; rift initiation; strain localization and delocalization processes: lithospheric stretching, buoyancy forces and lower crustal flow, lithospheric flexure, strain induced weakening, rheological stratification of lithosphere, magma assisted rifting; rifted continental margins: volcanic margins, non-	2

	volcanic margins, evolution of rifted margins; Case studies: the transition from rift to rifted margin: East African Rift System, The Wilson cycle.	
Continental transforms and strike-slip faults	Fault styles and physiography; deep structure of continental transforms: The Dead Sea Transform, The San Andreas Fault; Transform continental margins; continuous versus discontinuous deformation: relative plate motion and surface velocity fields; strain localization and delocalization mechanisms: lithospheric heterogeneity, strain softening feedbacks; Measuring the strength of transforms	2
Subduction zones	Ocean trenches, general morphology of island arc systems, gravity anomalies of subduction zones, structure of subduction zones from earthquakes, thermal structure of the down going slab, variations in subduction zone characteristics, accretionary prisms, volcanic and plutonic activity, metamorphism at convergent margins, backarc basins	2
Orogenic belts	Ocean–continent convergence: seismicity, plate motions and subduction geometry; compressional sedimentary basins: foreland basins, basin inversion, modes of shortening in foreland fold-thrust belts; continent–continent collision: relative plate motions and collisional history, surface velocity fields and seismicity, general geology of the Himalaya and Tibetan Plateau, deep structure, mechanism of continental collision; arc–continent collision, Terrane accretion and continental growth	2
Precambrian tectonics and the supercontinent cycle	Precambrian heat flow; Archean tectonics: general characteristics of cratonic mantle lithosphere, general geology of Archeancratons, formation of Archean lithosphere, crustal structure, horizontal and vertical tectonics; Proterozoic tectonics: general geology of Proterozoic crust, continental grown and craton stabilization; the supercontinent cycle	2

Textbooks:

1. Philip Kearey, Keith A. Klepeis and Frederick J. Vine, 2009.Global Tectonics.Third Edition.Wiley-Blackwell, Oxford, 496 p.
2. Frisch, W., Meschede, M. and Blakey, R., 2011. Plate Tectonics: Continental Drift and Mountain Building. Springer,212 p.

References:

1. Dhital M.R., 2015. Geology of the Nepal Himalaya: Regional Perspective of the Classic Collided Orogen. Springer, 498 p.
2. Lowrie, W., 1997. Fundamentals of Geophysics. Cambridge University Press, 354 p.
3. Press, F., Siever, R., Grotzinger, J., Jordan, T., 2003. Understanding Earth. 4th edition. Freeman, New York, 568 p.
4. Rob Van der Voo, 1993. Paleomagnetism of the Atlantic, Tethys and Iapetus Oceans. Cambridge University Press, 416 p.

5. Spencer, E.W., 1977. Introduction to the Structure of the Earth, McGraw Hill Kogakusha, 640 p.
6. Stuwe, K., 2007. Geodynamics of the Lithosphere: Quantitative of Geological Problems. 2nd Edition. Springer-Verlag, 493 p.
7. Turcotte, D.L., Schubert, G., 2002. Geodynamics: Applications of Continuum Physics to Geological Problems. 2nd edition. Cambridge University Press, Cambridge, England, 456 p.

Part B: Seismology(1 Cr., 15 hours)

General objectives:
To give basic knowledge of seismology
Specific objectives
To provide students' knowledge of seismic wave propagation, seismic source characteristics, seismicity analysis.

Title	Content	Hrs.
Seismic wave propagation	Stress-strain and equation of motion,	1
	Seismic waves: seismic wave equation, body waves and surface waves,	2
	Seismogram and different seismic phases	1
Earthquake phenomenology	Seismic source: point source and finite fault source,	1
	Radiation pattern of body waves and double couple source,	1
	Different magnitude scales of earthquake	1
	Saturation of magnitude scales, seismic energy and seismic moment	2
Seismicity analysis	Global seismicity and plate tectonics, Focal mechanism solutions,	2
	Earthquake catalog, distribution of earthquakes in time and space, Background seismicity, foreshock, main shock and aftershock, aftershock distribution and Omori's law,	2
	Interseismic period and coseismic activities, Earthquake magnitude and frequency, Richter-Gutenberg relation, Earthquake sequences	2

Textbooks:

Textbooks:

1. Shearer, Peter M. (2009). Introduction to Seismology Second Edition, Cambridge University Press, 412p.

2. Scholz, Christopher H. (2002). The Mechanics of Earthquake and Faulting Second Edition, Cambridge University Press, 471p.
3.

References:

1. Chapman, Chris H. (2004). Fundamentals of Seismic Wave Propagation, Cambridge University Press, 617p.
2. Aki, K. and Richards, P. G. (2009) Quantitative Seismology, University Science Books, 700p.
3. Stein, S. and Wysession, M. (2003). An Introduction to Seismology, Earthquakes and Earth Structure. Blackwell Publishing, 498p.

Geo.654: Practical of Geo.651 and Geo.652

Semester	**IV**
Course Title	**Practical of Geo.651 and Geo.652**
Course Code	**Geo.654**
Subjects	**Techniques of Structural Analysis (1 Cr.), Applied Geomorphology and Neotectonics (1 Cr.)**
Credits	**1**
Teaching hours	**45 hrs.**
Full Marks	**25**
Pass Marks	**12.5**
Nature of the course	**Practical**

Part A: Techniques of Structural Analysis (21 hours)

Lab 1: Principles of displacement and strain using simple shear of a card deck.
Lab 2: The strain ellipse concept – distortation and rotation.
Lab 3: Calculation of ellipticity from the distorted clast.
Lab 4: Displacement vector fields and strain.
Lab 5: Calculation of nature of strain by different methods, Measurement of strain in extended and shortened feature.
Lab 6: Projection of plane before and after deformation, Projection of a line before and after deformation.
Lab 7: Classification of folds using Ramsay's classification

Textbooks

1. Ramsay, J. G. (1967): *Folding and Fracturing of Rocks*, McGraw Hill Inc., *568* p.
2. Turner, F. and Weiss, L. E. (1963): *Structural Analysis of Metamorphic Tectonites*, McGraw Hill Book Company, *545* p.
3. Passchier, C. W. and Trouw R. A. J. (2003): *Micro-tectonics*, Springer, 253 p.
4. Ramsay, J. G. and Huber, M. I (1983): *The Techniques of Modern Structural Geology, Volume 1: Strain Analysis*, Academic Press, 307 p.
5. Ramsay, J. G. and Huber, M. I (1987): *The Techniques of Modern Structural Geology, Volume 2: Folds and Fractures*, Academic Press, 309-700 p.

References:

1. Bayly, B. (1991): *Mechanics in Structural Geology*, Springer-Verlag, 253 p
2. McClay, K. R. (1987): The Mapping of Geological Structures, John Wiley & Sons Inc., 161 p.
3. Ragan D. M. (1985): *Structural Geology, An Introduction to Geometrical Techniques*,3rd edition,John Wiley & Sons Inc., 393 p.
4. Means W. D. (1985): *Stress and Strain Basic concepts of continuum mechanics for geologists*, Springer-Verlag New York, 339 p.

Part B: Applied Geomorphology and Neotectonics (24 hrs.)
Applied Geomorphology (12 hrs.)
Lab 1: Study of Geomorphological cycle, weathering and mass wasting processes.

Lab 2: Study of landforms in different geological terrain, and morphometric study of drainage basin
Lab 3: Morphometric study of drainage basin.
Lab 3: Geomorphological mapping, and survey techniques.
Lab 4: Hazard map preparation.
Lab 6: Geomorphological survey techniques.

Neo-tectonics (12 hours)
Lab 1: Interpretation and preparation of Neotectonic Map of the given area using remote sensing technique of different platform.
Lab 2-Lab 3: Estimation of Slip, Uplift and convergence rate from the flight of different level of terraces, Interpretation of trench log to calculate co-seismic slip and uplift
Lab 4: Establishing timing in the landscape: dating methods

Textbooks:

1. Douglas W. Burbank and Robert S. Anderson, (2012). Tectonic Geomorphology, 2nd Edition. 474 p.
2. William B. Bull, (2007). Tectonic Geomorphology of Mountains, 1st Edition, 329 p.
3. Andrew Goudie et al., (1990). Geomorphological Techniques, 2nd Edition, 10 p.

Geo.655: Dissertation

Semester	**IV**
Course Title	**Dissertation**
Course Code	**Geo.654**
Subjects	**Applied Geology**
Credits	**4**
Full Marks	**100**
Pass Marks	**50**
Nature of the course	**Field and Laboratory Research**

Course Description: Dissertation work is an important component of the curriculum of MSc 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 research. However, the proportion of field and lab-work may vary depending upon the type of project selected.

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:

Students have to carry out dissertation research and submit a dissertation at the end of IVth Semester. Students must carry out dissertation work in one of the disciplines within the specialization courses of Applied Geology offered in the curriculum.

Before the start of the dissertation work, the students must prepare a research proposal and submit to the department through the assigned supervisor/s. 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 student should carry out at least of 4 weeks duration field work for the dissertation. 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.

Each supervisor will be allowed a maximum of 7 days leave to go to the field with their students for supervision of the work upon the request of the student.

Geo.661: Climate Change and Groundwater

Semester	**IV**
Course Title	**Climate Change and Groundwater**
Course Code	**Geo.661**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

Course Description: This course provides the students with the concepts of climate change and climate induced impact on groundwater occurrence and thereby help to adapt in the changed context.

General Objective: To provide in-depth understanding of climate change and its impact to groundwater.

Specific Objective: To provide the students with in-depth knowledge and practical skills on climate change related effect to groundwater:

- Fundamental concepts on natural and human-induced climate change
- Assessment of climate change
- impacts of climate change in various sectors and adaptation techniques
- Assessment of change in groundwater availability
- Protection and enhancement of groundwater resources
- Alternate options to cope with the problem

Course content:

Title	Details	Hrs.
Fundamental Concepts	Basics of climate change; evidence of climate change; Groundwater and Hydrologic Cycle, Climate variability, causes. Climate change challenge, Climate monitoring, Hydrologic variability, Extreme events.	4
Projected Future change: Direct Impact	Impacts on various sectors; Effects of climate change on groundwater resources; Effects of climate change on groundwater resources; Climatological cycles in groundwater levels; impact to springs due to climate change, Quantifying the impacts of climate change on groundwater in an unconfined aquifer; Transient response of groundwater systems to climate changes	6
Projected Future change: Indirect Impact	Implications for groundwater dependent systems and sectors; Rural and urban communities; Urban pressure; Agriculture; Ecosystems; Uncertainties and knowledge gaps.	2
Adaptation to Climate Change	Concept of adaptation; preparing for adaptation; Framework for adaptation a) Climate monitoring b) Water demand analysis c) Diversification of water sources d) Enhancing storages	4

	Forms of adaptation, Adaptation options for risks to groundwater dependent systems from climate change and hydrological variability	
Vulnerability and adaptive capacity assessment	Adaptation options for risks to groundwater dependent systems from climate change and hydrological variability; Building adaptive capacity for groundwater management; Managing groundwater recharge; Protecting groundwater quality; Managing groundwater storages; Managing demand for groundwater; Management of groundwater discharge; Managing for increased groundwater recharge; Avoiding adaptation decision errors; Evaluation of adaptation options; Barriers to introduction of adaptations; Groundwater management strategies to reduce vulnerabilities	6
Adaptation to climate change and hydrological variability from developing countries - Case studies	Managed aquifer recharge; Groundwater Protection; adaptations and challenges for a low atoll; Case studies (e.g. MAR example: sand dams in Kenya); the future of groundwater recharge with reclaimed water	3
Groundwater modeling to study impacts	Outcome of climate modeling in Nepal Himalaya and its impacts in groundwater; groundwater modeling to generate model predicting impact on groundwater, .its use and limitations.	2
Economic considerations	Water energy food nexus	1
governance	Improved groundwater governance Gender, climate change and groundwater	2

Textbooks:

1. Dragoni, W. & Sukhija, B. S. (eds) 2008. Climate Change and Groundwater. Geological Society, London, Special Publications, 288.
2. Treidel, H. J., Martin-Bordes, L. and Gurdak J. J. (Eds:), 2011. Climate Change Effects on Groundwater Resources - A Global Synthesis of Findings and Recommendations. International Association Of Hydrogeologists, CRC Press.
3. Groundwater and Climate Change: Challenges and Possibilities. Groundwater Resource and management. BGR Geo Center Denmark.

References:

1. Gosain, A. K., Shrestha, A. B., and Rao, S., 2010. Modelling climate change impact on the hydrology of the Eastern Himalayas; Climate change impact and vulnerability in the Eastern Himalayas – Technical report 4. Kathmandu: ICIMOD.
2. Pathak, D; Gajurel, AP; Mool, PK (2010) Climate change impacts on hazards in the Eastern Himalayas; Climate change impact and vulnerability in the Eastern Himalayas – Technical report 5. Kathmandu: ICIMOD

3. Water and Climate Change: Impacts on groundwater resources and adaptation options' Craig Clifton Rick Evans Susan Hayes Rafik Hirji Gabrielle Puz Carolina Pizarro. Water Working Notes no 25, June 2010.
4. GRAPHIC Groundwater and Climate Change.Position Paper and call to action
5. Impacts, adaptation a vulnerability; working Group II, Climate Change IPCC.
6. Journal of Hydrology.

Geo.662: Groundwater Exploitation

Semester	**IV**
Course Title	**Groundwater Exploitation**
Course Code	**Geo.662**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

Course Description: This course provides the students with the concepts of ground water utilization in different aspects like drinking, irrigation and industrial purposes.
General objective: Provide in depth understanding of sustainable development of ground water.
Specific objective:

- Exploitation of ground water using different methods/ techniques.
- Give knowledge on optimum and multiuse of groundwater
- Precautionary measures in ground water uses.

Course content:

Title	Contents	Hrs.
Assessment of water requirement	Types of use (domestic, industrial, irrigation, etc.), Availability of water resources, estimation of well capacity and beneficiaries use, well site selection.	2
Construction and design	Types of ground water well, pilot bores, drilling techniques, sampling and logging, types and use of tube well drilling bits (button bit, drag bit, rock roller bit etc.),casing diameter, casing materials, well depth, well screen type, well screen, slot openings, well screen diameter, open area, entrance velocity, screen transmitting capacity, selection of materials, design of domestic wells, design for sanitary protection, special well design (dug well, open well construction, well size, depth estimation, screened depth, screened length and its opening, well assembly specification, well protection, well cleaning and development), Rate analysis, Estimating and costing of tube well.	5
Well yield and Abstraction limits	Well yields, Regional abstraction limits, Estimating ground water use, Recharge and volume in storage, Recharge area and recharging well, Impact of droughts on ground water supply and use, conjunctive use of ground water and surface water, Scheduling deliveries in projects with limited supplies, Ground water monitoring technology, artificial recharge, managing ground water supplies.	5
Pumping	Pump classification and terminology, Power of pump, Energy supply to pump(solar, diesel, electricity)Pump suction	5

Equipment/tools	conditions and beyond the suction conditions, Specification of pumps, Pumps for deep and shallow tube wells, selection of pump materials,, Plant requirements and pump house design and safety precautions.	
Ground water distribution systems	Shallow tube well systems, Deep tube well systems, Open channels and buried pipe distribution systems and its advantages. Supporting structures in tube well systems, users' participation and project promotion, activities and participants in water supply planning.	3
Water Quality Protection for wells and nearby ground water resources	Quality of water in accordance with urban, irrigation and industrial needs, choosing a well site, predicting the pollutions potential at a drilling site and well design, Disinfection procedures required to maintain sanitary well during drilling, Sealing the well heads, Sealing abandoned wells.	5
Well and Pump maintenance and Rehabilitations	Major causes of deteriorating well performance, well failure caused by incrustation, well failure caused by iron bacteria, well failure caused by physical plugging of screen and surrounding formation, Importance of screen design on rehabilitation, well failure from corrosion, Safety measures of pump operation and its maintenance, Role of water users in ground water distribution system management, Estimating and costing of O &M of pumps and tube wells.	5

Textbooks:

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

References:

1. Freeze R.A., Cherry J.A. (1979): Groundwater, Prentice Hall.
2. Fetter, C.W., (1994): Applied hydrogeology. McMillian, new York
3. Raghunath, H.M.(2006), Ground Water, New Age International Private Limited, New Delhi
4. M.6, Ground water irrigation Manual, (1990),Sir MacDonald and Partners.

Geo.663: Groundwater Resources and Water Laws of Nepal

Semester	**IV**
Course Title	**Groundwater Resources and water laws of Nepal**
Course Code	**Geo.663**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

Course Description: Groundwater resource is estimated to be high in Nepal especially in the southern plains of Terai but limited in the hilly regions which make it complicated when sharing this resource especially where the resource is limited. Existing acts, regulations cover entire water resources including groundwater. The course is expected to shed challenges it its use especially as the demand increases.

General objective: To Provide in depth knowledge of existing groundwater resources of Nepal and its existing regulations for its use.

Specific objective: To provide

-Knowledge of groundwater resources in various physiographic divisions of Nepal
-Its uses, recharge conditions
-Existing rules and regulations and the prevailing practices.

Course content

Title	Details	Hrs.
Introduction	Groundwater occurrence in different physiographic regions of Nepal, hydrological, meteorological, geological and structural control on the occurrence and distribution of groundwater.	2
Groundwater in Higher Himalaya	Permafrost regions and its impact on discharge. Hot springs	3
Groundwater in Lesser Himalaya	Potential hard rock aquifer and their distribution, Spring sources, their distribution and impact, quality	3
Groundwater in Intermontane basin	Kathmandu valley, Pokhara valley, their potentials, current use, quality.	4
Groundwater in Doon valley	Chitwan, Surkheturket, Dang aquifer type, distribution, potential and current status.	4
Groundwater in Terai Region	Bhabar zone, Terai plains: aquifer types and distribution, their potential, and current status.	4

Water resources Plan, policies, strategy, act of Nepal	Existing water laws, regulations, policy and strategies, national water plan, Water resources strategy, line ministries and agencies. Water resources act; Riparian law, Appropriation law.	6
Groundwater related policies and acts	General groundwater policies, acts; Groundwater law: Common law or statutory law; groundwater policy of Kathmandu valley; Groundwater law: Common law or statutory law. Case studies: Texas groundwater law, Arizona groundwater management code, case study from California, Ownership guide on groundwater	4

Textbooks:

1. Water Resources strategy of Nepal, 2002
2. National water Plan of Nepal, 2005

References:

1. Journal publications
2. Publications from government of Nepal and line agencies

Geo.664: Practical of Geo.661 and Geo.662

Semester	**II**
Course Title	**Practical of Geo.661 and Geo.662**
Course Code	**Geo.664**
Subjects	**Climate Change and Groundwater (1 Cr.), Groundwater Exploitation (1 Cr.)**
Credits	**2**
Teaching hours	**90 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Practical**

Part A: Climate Change and Groundwater (1 Cr., 45 hrs.)

Lab 1: Review and draw diagram with the paleo-climate change and recent climate change (after 1960) trend: Global and national perspective.
Lab 2: Groundwater regime in Nepal at various physiographic regions and assess possible impact in the extent of climate change.
Lab 3: Assess spatial variation in mean annual rainfall in Nepal, 1960 onwards.
Lab 4: Assess spatial variation in annual temperature in Nepal, 1960 onwards.
Lab 5: Estimate groundwater recharge in mountainous region with respect to rainfall before climate change and after climate change (in the mountain watershed where climate modeling has been done).
Lab 6: Estimate groundwater recharge in Terai with respect to rainfall before climate change and after climate change (where climate modeling has been done).
Lab 7: Propose adaptation and mitigation measures to ensure groundwater availability in those regions (Mountainous and Terai) with respect to best available techniqe and socio-economic condition.

Part B: Ground water exploitation (1 Cr., 45 hrs.)

Lab 1: Analysis of Pumping Test Data
Lab 2: Discharge calculations, and Technical specification of casing, strainer and pumps,.
Lab 3: Cost estimating of tube well, Pumps and other parts of distribution system.
Lab 4: Estimating rehabilitation requirements of the project and its anticipated result.
Lab 5: Case studies:Different rehabilitation of ground water distribution systems. Management of the ground water utilization systems in the area ??
Add some more practical.

Geo.665: Dissertation

Semester	**IV**
Course Title	**Dissertation**
Course Code	**Geo.665**
Subjects	**Hydrogeology**
Credits	**4**
Full Marks	**100**
Pass Marks	**50**
Nature of the course	**Field and Laboratory Research**

Course Description: Dissertation work is an important component of the curriculum of MSc 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 research. However, the proportion of field and lab-work may vary depending upon the type of project selected.

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:
Students have to carry out dissertation research and submit a dissertation at the end of IVth Semester. Students must carry out dissertation work in one of the disciplines within the specialization courses of Hydrogeology offered in the curriculum.

Before the start of the dissertation work, the students must prepare a research proposal and submit to the department through the assigned supervisor/s. 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 student should carry out at least of 4 weeks duration field work for the dissertation. 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.

Each supervisor will be allowed a maximum of 7 days leave to go to the field with their students for supervision of the work upon the request of the student.

Geo.671: Mine Design, Planning and Management

Semester	**IV**
Course Title	**Mine Design, Planning and Management**
Course Code	**Geo.671**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

Course Description: This course provides the students with the concepts of mine design, planning and management. It deals with the strategic and tactical decision making processes in mining.

General Objective: To provide skills of mine design, planning and management essential for mining industry.

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

- Mine planning in relation to technology and economics with due consideration of environment,
- Selection and preparation of mine plan and design,
- Management of mine works and environment.

Course Contents:

Topics	Details	Hrs.
Introduction	Objectives, Principles and Process of mine planning; Scientific and engineering approach to mine design and strategic planning; Stages of mine planning - Long Range Planning, Short Range Planning; Technical, Economical and environmental information required for mine planning; Techno-economics of opencast versus underground mining operations.	4
Surface Mine Planning	Determination of optimum output, life of a mine and size of mine, Taylor's mine life rule, ultimate pit configuration. Optimum location of mine entries, Technical and economic considerations in opening up, bench formation and ultimate pit configurations; Determining Pushback Parameters, Pushback Selection/Mining Sequence, Production planning and scheduling, calendar plan, mine equipment planning, Grade control strategies, infrastructure planning. Systems of overburden removal and planning of layouts for stipulated production; Drainage Planning and Arrangement, Reclamation Planning - Planning for reclamation of mined out areas, open pits, waste dumps and tailings pond, The Detailed Mine Plan, Surface Plan.	10
Underground Mine Planning	Capacity of a Mine; Delineation of mining area; Annual output and life of the mine; Design of mine entry systems- Opening of single and multiple seams/veins at various	10

	inclinations – Type (shaft, incline or adit), number, location and design; Division of the mining area into working units on district and level pattern.	
Computer aided mine designing	Preparation of mine plan map, and corresponding section map, mineable reserve and average assay using GIS, AutoCad and Excel systems;	6

Textbooks:

1. Hustrulid, W. A. and Kuchta, M. (1995). Fundamentals of open pit mine planning and design Vol I & Vol II. Elsevier.
2. Hustrulid, W. A. (1982). Underground Mining Methods Handbook Society for Mining Metallurgy.
3. Rzhevsky, V. V., (1985). Opencast Mining Technology and Integrated mechanization, Mir Publishers, Moscow
4. Hartman, L. (1997). Introductory Mining Engineering, John Wiley and Sons Inc, 584p.
5. Bhattacharya, J. (2003). Principles of Mine Planning. Allied Publishers, Delhi.
6. Mathur, S. P. (1993). Mine Planning for Coal, MG Consultants Bilaspur, 295p.

References:

1. Hartman, S. M. E. (1992). Mining Engineering Handbook, Vol. I & II., Society for Mining.
2. Metallurgy and Exploration Inc. 1992.
3. Singh, T. N. (1992). Underground Winning of Coal, Oxford IBH.
4. Das, S. K. (1996). Modern Coal Mining Technology Lovely Prakashan, Dhanbad.
5. Singh, R. D. (1997). Principles & Practices of Modern Coal Mining, New Age International (P) Ltd.
6. Boky, B. (1967). Mining, Mir Publishers.
7. Singhal, R. K.(Ed.) (1988). Mine Planning and Equipment Selection, A. A. Balkema.

Geo.672: Mineral Economics

Semester	**IV**
Course Title	**Mineral Economics**
Course Code	**Geo.672**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

Course Description: This course provides the fundamental principles of economic rules that help understanding of economic and legislation issues associated with the production, use and sale of mineral commodities.

General Objective: To provide in-depth understanding of mineral economics and every step of the mining process and marketing.

Specific Objectives: To make the students able to

- understand frequently used economic terminology
- comprehend particularities of mining industry and mining processes
- discern mineral legislation and related polices
- acquire knowledge on mineral marketing

Course Contents:

Topics	**Details**	**Hrs.**
Introduction	Background, Concept, objectives, scope of study	1
Mining Economy	Special features of mineral and mining industry, Tenor, grade and specification, Strategic, critical and essential minerals, Future sources of mineral supply, Conservation and substitution	5
Mine examination and valuation	Goal and strategies, Methods of Investment Analysis, Cost Benefit analysis, Risk analysis, Capital investment and financing	7
Mineral Processing	Comminution, Sizing, Concentration and Storage	5
Legal Framework for mineral development	National Mineral Policy, Mining and related laws of Nepal	6
Mineral Marketing	Market structure, Market organization, Mineral demand and forecasting, Mineral price and pricing,	6

Textbooks:

1. Sinha, R.M. and Sharma, N. L. (1970). Mineral Economics: a text book for university students. New Delhi: Oxford & IBH Pub. Co., 317 p.

2. Gocht, W. R., Zantop, H. & Eggert, R. G. (1988). International Mineral Economics. Springer-Verlag, Berlin.

References:

1. Anderson, F.J. (ed.) (1987). Selected Readings in Mineral Economics. Pergamon Press, New York, USA.
2. Sobczyk, E.J. & Kicki, J. (eds.) (2008). International Mining Forum 2008: Economic Evaluation and Risk Analysis of Mineral Projects. Taylor & Francis Group, London, UK.
3. Maxwell, P. & Guj, P. (eds.) (2013). Australian Mineral Economics. Australasian Institute of Mining and Metallurgy, Carlton, Victoria, Australia.

Geo.673: Mine Environment and Safety Engineering

Semester	**IV**
Course Title	**Mine Environment and Safety Engineering**
Course Code	**Geo.673**
Credits	**2**
Teaching hours	**30 hrs.**
Full Marks	**50**
Pass Marks	**25**
Nature of the course	**Theory**

Course Description: This course provides the fundamental principles of Mine Environment, Climate, Mine Ventilation and Occupational Health and Safety in and around mines that help to understand how occupational health and safety can be maintained in the mines.

General Objective: To provide in-depth understanding of Mine environment, occupational health and safety in the mines

Specific Objective: To make the students able to

- understand mine climate and environmental climate
- Generalize thermodynamics treatment of air flow in mines and ventilation measuring instruments
- Ventilation surveying and planning vis-à-vis different mining methods
- A through treatment of gaseous pollutants and airborne dust in the mine atmosphere, health hazards due to pollutants, modern instruments and techniques in the measurement and control of pollutants and diseases.
- Get knowledge about mine hazards and safety against different hazards, accident.
- Familiarize with first aid services and rescue procedure in case of an accident.
- Get information about statutory provisions and organization about environment, safety, and rescue management in Nepal.

Course Contents:

Topics	Details	Hrs.
Introduction	Background, Concept, objectives, scope of study	1
Mining Environment	Composition and effects of mine air, Sampling and Analysis, Mine dust and its hazard, Noise, Vibration.	5
Natural and Mechanical Ventilation	Causes, amount and direction of Natural Ventilation, Artificial aids to natural ventilation, fans, pumps and compressor, distribution and control of air currents	5
Ventilation Surveys and Planning	Important of survey, survey interval, survey records, measurement of flow quantity, measurement of velocity, manometers. plate orifices.	5
Occupational Health	Harmful gases, health hazards in mines, Diseases connected with mining operations, Periodic medical examinations.	4
Safety Engineering	Classification of accidents, causes of accident, reduction of accident, precaution during blasting, hauling, electricity supply, underground mine safety. surface mine safety.	4
First Aid, Rescue	first aid services in mine, first aid treatment, first aid equipment, Rescue apparatus, rescue stations, rescue room, rescue team.	3
Legal Provision	Environmental Protection Law, Mines and Minerals Law, Health	3

about environment and safety in Nepal	Law, Traffic Law, Compensation Law, Rastriya Bipad Byabasthapan Sangathan etc.	

Textbooks:

1. Misra, G.B, (1988). Mine Environment and Venatilation, Oxford University Press Culcutta, India, 619P
2. McPhenson. M.J, (1993). Subsurface Ventilation and Environmental Engineering, Springer Science + Business Media, B.V. 892P
3. Ghatak, S, (1986), Mine Management Legislation and General Safety.

References:

1. Pele, R., Church, J.A, Mining Engineer's Handbook, Third Edition 2442P

Geo.674: Practical of Geo.671

Semester	**II**
Course Title	**Practical of Geo.671**
Course Code	**Geo.674**
Subjects	**Mine Design, Planning and Management**
Credits	**1**
Teaching hours	**45 hrs.**
Full Marks	**25**
Pass Marks	**12.5**
Nature of the course	**Practical**

Course Contents:

Lab 1: Estimation of reserve based on borehole data of limestone deposit.
Lab 2: Estimation of reserve based on borehole data of Iron ore deposit
Lab 3: Estimation of reserve based on borehole data of Lead zinc deposit
Lab 4: Design of drive in a lead zinc mine. (Ganesh Himal)
Lab 5: Design of Raise/ winge in a metal mine.
Lab 6: Design of shaft in a lead zinc mine.
Lab 7: Design of length of long wall face.
Lab 8: Mining Geometrical Analysis: Selection of quarry area, Bench geometry: Bench height, bench width, bench slope. Pit geometry: Ultimate pit slope.
Lab 9: Design of box cut, haul road, waste disposal and stock pile in an open pit mine.
Lab 10: Selection mining plant and machinery
Lab 11: Problem related to mine scheduling

Textbooks:

1. Hustrulid, W. A. and Kuchta, M. (1995). Fundamentals of open pit mine planning and design Vol I & Vol II. Elsevier.
2. Hustrulid, W. A. (1982). Underground Mining Methods Handbook Society for Mining Metallurgy.
3. Rzhevsky, V. V., (1985). Opencast Mining Technology and Integrated mechanization, Mir Publishers, Moscow
4. Hartman, L. (1997). Introductory Mining Engineering, John Wiley and Sons Inc, 584p.
5. Bhattacharya, J. (2003). Principles of Mine Planning. Allied Publishers, Delhi.
6. Mathur, S. P. (1993). Mine Planning for Coal, MG Consultants Bilaspur, 295p.

References:

1. Hartman, S. M. E. (1992). Mining Engineering Handbook, Vol. I & II., Society for Mining. Metallurgy and Exploration Inc.
2. Singh, T. N. (1992). Underground Winning of Coal, Oxford IBH.
3. Das, S. K. (1996). Modern Coal Mining Technology Lovely Prakashan, Dhanbad.
4. Singh, R. D. (1997). Principles & Practices of Modern Coal Mining, New Age International (P) Ltd.
5. Boky, B. (1967). Mining, Mir Publishers.
6. Singhal, R. K.(Ed.) (1988). Mine Planning and Equipment Selection, A. A. Balkema.

Geo.675: Dissertation

Semester	**IV**
Course Title	**Dissertation**
Course Code	**Geo.675**
Subjects	**Mining Geology and Mineral Exploitation**
Credits	**4**
Full Marks	**100**
Pass Marks	**50**
Nature of the course	**Field and Laboratory Research**

Course Description: Dissertation work is an important component of the curriculum of MSc 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 research. However, the proportion of field and lab-work may vary depending upon the type of project selected.

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:
Students have to carry out dissertation research and submit a dissertation at the end of IVth Semester. Students must carry out dissertation work in one of the disciplines within the specialization courses of Mining Geology and Mineral Exploitation offered in the curriculum.

Before the start of the dissertation work, the students must prepare a research proposal and submit to the department through the assigned supervisor/s. 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 student should carry out at least of 4 weeks duration field work for the dissertation. 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.

Each supervisor will be allowed a maximum of 7 days leave to go to the field with their students for supervision of the work upon the request of the student.