

TRIBHUVAN UNIVERSITY
INSTITUTE OF SCIENCE AND TECHNOLOGY
MASTER OF SCIENCE IN GEOLOGY
(MSc Geology)

COURSE STRUCTURE
AND
CURRICULUM
(REVISED)
2080

Submitted by
Central Department of Geology
Tribhuvan University
Kirtipur, Kathmandu
Nepal

Introduction

The Central Department of Geology (CDG) was established in the Tribhuvan University in 1976. CDG has been offering international standard academic syllabus for the Master of Science in Geology since its establishment in 1976. CDG offers not only theoretical and laboratory based teaching but also extensive field work techniques, in order to build students capacity to work in various fields, such as tunnels, roads, bridges, dams, mining industries, and groundwater. CDG has been known for producer of competitive geoscientists with outstanding academic results, Courses offered by CDG are designed to maximize employment prospects through acquisition of subject knowledge and practical skills. The Geology Subject Committee regularly revises its courses to meet the new requirements in a changed context,

The CDG has decided to introduce Semester System from academic year (2013) to meet the contemporary needs of the country as well as to make the level of education at par with the international standards. Accordingly, the Geology Subject Committee prepared course structure and curriculum for four semesters. The course was revised in 2015 and 2017. Tribhuvan University started Master of Science in Engineering Geology at the CDG and Tri Chandra College from 2016. The Geology Subject Committee has decided to make appropriate revisions in the MSc Geology course and implement it from the 2080 batch.

Aims and Objectives

The main aim of the Course is to create professionals having in depth knowledge and skills in the field of geology. Apart from it, the course also aims at producing specialists able to follow integrated and multi disciplinary approaches in their profession. After the completion of the course in geology the students will be able to carry out the professional work, research and /or advance studies independently.

Eligibility for Admission

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

Admission Criteria

The applicants will have to appear in an entrance examination conducted by the Institute of Science and Technology, Tribhuvan University. An applicant who fails to appear in the Entrance Examination or fails to obtain a minimum qualifying score will not be allowed admission. A merit list of the qualified applicants will be prepared based on the marks obtained by them in the Entrance Examination. Admission of the students will be based strictly on the merit list and the enrolment capacity of the Central Department of Geology.

Medium of Instruction

English

Duration of the program

Four semesters completed in two academic years (4 academic semesters). There will be common courses for all students in the first, second and third semesters. In the fourth semester, the students will be assigned one special course from four Elective Groups designed according to their proposal for dissertation topic in the third semester. A student should complete the course within 5 years (10 academic semesters).

Hours of Instruction and credit calculation

Working days: 90 days per semester

Semesters: 4

Total credits: 69

Full Marks: 1725

Theory

One credit = 15 hours and 25 marks

One theory paper of 1 credit will have one hour of lecture per week

Practical

One credit 45 lab work hours and 25 marks.

One practical paper of 1 credit will have 3 hours of practical per week

Field work

One credit 70 field work hours/week (10 hours/day) and 25 marks,

A fieldwork for a period of 8 weeks will be given to each student of the M.Sc. course in Geology. There will be two fieldworks each of four weeks duration (one in the First Semester and the other in the Third Semester) and each of them will carry 4 credits.

Dissertation

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

Evaluation

Theory paper

Forty percent (40%) marks as Internal Assessment is assessed by concerned teacher on the basis of seminar, term-paper or internal examination. 60% mark is allocated for Final examination. Without passing internal exam students will not be qualified to appear in the semester exam.

Practical

The Practical work is evaluated separately (100%)

Dissertation

The dissertation will be submitted to the Central Department of Geology. The dissertation will be forwarded to the Institute of Science and Technology (IOST), Tribhuvan University for examination. The external examiner will be assigned by the IOST and internal examiner will be assigned by the CDG. A committee of head of department of CDG, external examiner, internal examiner and dissertation supervisor will examine the dissertation. The student should compulsorily attend the viva voce examination of the dissertation.

Grading

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

Grade	CGPA	Percentage Equivalent	Performance Remarks
A	4.0	90 and above	Distinction
A ⁻	3.7	80-89.9	Very Good
B ⁺	3.3	70-79.9	First Division
B	3.0	60-69.9	Second Division
B ⁻	2.7	50-59.9	Pass in individual Subject
F	0	Below 50	Fail

Certificate

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

MSc Geology Course Structure (2080)

Semesters	SN	Course code	Course name	Credits	Marks	
First	1	GEO 511	Igneous Petrology	2	50	
	2	GEO 512	Metamorphic Petrology	2	50	
	3	GEO 513	Mineralogy	2	50	
	4	GEO 514	Sedimentology	2	50	
	5	GEO 515	Structural Geology	2	50	
	6	GEO 516	Stratigraphy and Microplaeontology	2	50	
	7	GEO 517	Pracctical of GEO 511 and GEO 512	2	50	
	8	GEO 518	Pracctical of GEO 513 and GEO 514	2	50	
	9	GEO 519	Pracctical of GEO 515 and GEO 516	2	50	
	10	GEO 520	Field work	4	100	
			Total	22	550	
Second	1	GEO 551	Geology of Himalaya	2	50	
	2	GEO 552	Quaternary Geology and Paleoclimate	2	50	
	3	GEO 553	Environmental Sedimentology	2	50	
	4	GEO 554	Remote Sensing and GIS	2	50	
	5	GEO 555	Geology of Mineral Deposit	2	50	
	6	GEO 556	Exploration Geophysics	2	50	
	7	GEO 557	Practicals of GEO 551 and GEO 552	2	50	
	8	GEO 558	Practicals of GEO 553 and GEO 554	2	50	
	9	GEO 559	Practicals of GEO 555 and GEO 556	2	50	
			Total	18	450	
Third	1	GEO 611	Engineering Geology	2	50	
	2	GEO 612	Mining Geology	2	50	
	3	GEO 613	Hydrogeology	2	50	
	4	GEO 614	Exploration Geochemistry	2	50	
	5	GEO 615	Practicals of GEO 611 and GEO 612	2	50	
	6	GEO 616	Practicals of GEO 613 and GEO 614	2	50	
	7	GEO 617	Field work	4	100	
			Total	16	400	
Fourth			Elective Group I			
	1	GEO 651	Structural Analysis	2	50	
	2	GEO 652	Basin Analysis	2	50	
	3	GEO 653	Global Tectonics and Seismology	2	50	
	4	GEO 654	Practicals of Elective Group I	3	75	
				Elective Group II		
	1	GEO 661	Tunnel Engineering	2	50	
	2	GEO 662	Geohazard	2	50	
	3	GEO 663	Geological Construction Material	2	50	
	4	GEO 664	Practicals of Elective Group II	3	75	
				Elective Group III		
	1	GEO 671	Mineral Prospecting and Exploration	2	50	
	2	GEO 672	Mineral Resources of Nepal	2	50	
	3	GEO 673	Mineral Economics and Petroleum geology	2	50	
	4	GEO 674	Practicals of Elective Group III	3	75	
				Elective Group IV		
	1	GEO 681	Mountain Hydrogeology	2	50	
	2	GEO 682	Water resource and Climate Change	2	50	
	3	GEO 683	Hydrogeological Techniques	2	50	
	4	GEO 684	Practicals of Elective Group IV	3	75	
			Total	9	225	
		GEO 691	Dissertation	4	100	
			Total Credits 22+18+16+13 = 69	69	1725	

SEMESTER I

SN	Course code	Course name	Credits	Marks
1	GEO.511	Mineralogy	2	50
2	GEO.512	Sedimentology	2	50
3	GEO.513	Igneous Petrology	2	50
4	GEO.514	Metamorphic Petrology	2	50
5	GEO.515	Structural Geology	2	50
6	GEO.516	Stratigraphy and Microplaeontology	2	50
7	GEO.517	Practical of GEO.511 and GEO.512	2	50
8	GEO.518	Practical of GEO.513 and GEO.514	2	50
9	GEO.519	Practical of GEO.515 and GEO.516	2	50
10	GEO.520	Field work	4	100
		Total	22	550

GEO.511: MINERALOGY

Semester	I
Course Title	Mineralogy
Course Code	GEO.511
Full Marks	50
Pass Marks	25
Nature of the course	Theory
Credit	2 (30 hrs.)

Course Description: This course provides the students with the concepts of mineralogy dealing with crystal chemistry, optical mineralogy and systematic mineralogy.

General Objective: To give in-depth knowledge and understanding of mineral structure, chemistry, physical and optical properties and classification.

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

(Total credit=2, FM=50, Teaching hours= 30)

Title	Content	Teaching hours
Mineral Chemistry		
Coordination of ions	Importance of mineral chemistry, atomic radius, ionic radius, Elements and minerals, Modern Periodic Table, Radius ratio. Coordination principles. Bonding forces in crystal, Crystal structures: Packing of Spheres. Isostructuralism. Some common structure types. Polymorphism. Pseudomorphism.	4
Compositional Variation in Minerals	Substitutional solid solution: Simple and coupled substitutions, Interstitial solid solution, Omission solid solution, Variation diagrams. Exsolution.	2
Optical Mineralogy		
Nature of light	Polarized light. Isotropic and Anisotropic Crystals.	4
Uniaxial and biaxial crystals under plain polarized light	Uniaxial and biaxial crystals and indicatrices. vibration directions. Pleochroism. Relative Relief.	
Uniaxial and biaxial crystals between crossed polars	Extinction, Interference colour, Accessory plates. Birefringence, and Sign of elongation.	2
Uniaxial crystals under convergent light	Uniaxial interference figures; determination of optic sign of uniaxial crystals.	2
Biaxial crystals under convergent light	Biaxial interference figures; Determination of optic sign of biaxial crystals using various interference figures. Optic axial angle, Apparent optic axial angle and Dispersion in biaxial crystals.	2
Systematic Mineralogy		

Chemical formulae, structures, diagnostic properties and occurrences of following minerals	Nesosilicates (Olivine and Garnet groups). Inosilicates (Pyroxene group)	2
	Inosilicates (Amphibole group). Sorosilicates (Epidote groups). Cyclosilicates (Beryl and Tourmaline groups)	2
	Phyllosilicates (Clay mineral and Mica groups)	2
	Tectosilicates (SiO ₂ and Feldspar groups)	2
	Calcite and Dolomite groups, Anhydrite and Gypsum groups.	2
	Spinel and Hematite groups. Gem minerals	2
Advanced Analytical methods	Atomic Absorption Spectrometry (AAS), X-Ray Fluorescence Analysis (XRFA), Laser Ablation Coupling Techniques (LA-ICP-AES, LA-ICP-MS) Electron Microprobe Analysis (EMPA), X-ray Diffraction (XRD)	2

Text Books

1. Nesse, W. (2014). *Introduction to optical mineralogy*, Oxford University Press, 384p.
2. Blackburn, W H. and William, H.D. (1999). *Principles of Mineralogy*, Wm. C. Brown Publishers, 413p.
3. Klein, C. and Hurlbut, Jr. (1985). *Manual of Mineralogy*, John Wiley and Sons, 596p.
4. Tamrakar, N.K. (2011). *Practical Mineralogy*, CDGTU, Kirtipur, 184p.
5. Shelley, D. (1985). *Optical Mineralogy*, Elsevier Science Ltd, 2nd edition. 352p.

Reference Books

6. Phillips, W.R. and Griffen, D.T. (1986). *Optical Mineralogy, The no-opaque minerals*, CBS Publisher and Distributaries, Delhi, 677p.
7. Zussam, J. (1977). *Physical Methods in Determinative Mineralogy*, Academic Press, 720 p.
8. Sands, D.E. (1975). *Introduction to Crystallography*, Dover Publication Inc., New York, 165p.
9. Hutchison (1974). *Laboratory Methods in Petrography*, John Willey and Sons Inc. New York.
10. Kerr, P.F. (1971). *Optical Mineralogy*, McGraw-Hill, New York. 492p.

Geo.512: SEDIMENTOLOGY

Semester	I
Course Title	Sedimentology
Course Code	GEO.512
Full Marks	50
Pass Marks	25
Nature of the course	Theory
Credit	2 (30 hrs.)

Course Description: This course provides the students with sedimentology dealing with origin of sediments, transportation and deposition of sediment, and transformation of sediments to sedimentary rocks.

General Objective: To give in-depth knowledge and understanding of genesis, processes, applied aspects of sediments and sedimentary rocks.

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

- Identifying sediments and sedimentary rocks with their description, classification, nomenclature, and origin
- Analysing composition, texture, structure and provenance of sediments

(Total credit=2, FM=50, Teaching hours= 30)

Title	Content	Teaching Hours
Origin of Sediments		
Origin of Terrigenous Clastic Grains	Weathering and soil formation. Clastic sediments as chemical and physical weathering products: Rock forming minerals during weathering, Factors controlling rates of weathering, Goldich's Stability of sequence of rock forming minerals, Stability of common minerals under weathering, Geochemical differentiation of elements from weathering of rocks. Provenance: Siliciclastic sediment sourcing. Solid Breakdown products of older deposits.	3
Origin of Calcium Carbonate, Evaporites, Silica, Iron-rich and Phosphate Sediments	Particles that are not solid breakdown products of older deposits: <i>Authigenic Particles</i> : Carbonates as precipitates, biological origin, and non-skeletal carbonate grains. Evaporite salts. Silica sediments. Iron-rich sediments. Phosphates. Primary and microbial-induced sediments. <i>Pyroclastic particles</i> .	3
Properties of sedimentary particles, Pores and Permeability	Grain size, Distribution and characteristics of grain population. Graphic measures of size distribution. Grain shape and form. Mass properties. Pore morphology and origin of primary pores. Sedimentary fabrics: Sorting, packing, orientation of particles. Mass density of solid particles, Volumetric sediment concentration, specific weight of mixture, dynamic and kinematic viscosities of Newtonian mixtures.	3
Sediment Sedimented		

Sedimentological Fluid Dynamics, Transport of Sediment Grains, Sedimentation and Depositional Systems	Fluid basics: Fluid properties, Boundary layer. Channel roughness and resistance to flow: State of flow. Effect of fluid viscosity: laminar and turbulent flow, Reynolds number, Effect of gravity: Froude Number, Flow resistance equations: Chézy Equation, Manning Equation, Darcy-Weisbach Equation, Hydraulic flow-resistance factors; Estimating total roughness using Cowan's method. Flow path of grain motion. Grains in stationary fluid. Fall velocity. Flocculation.	3
	Erosion. Sediment Yield. Annandale's Erodibility Index. Sediment load: Modes of transport, Incipient motion and sediment transport. Bed shear stress. Bed load transport: deterministic, probabilistic and stream power approaches. Suspended load transport. Total sediment load. Sediment Transport Capacity: stream power. Sediment Deposition and Sediment characteristics: Aqueous processes: Lake or reservoir: settling velocity of mud and coarse grains. Flocculation. Subaqueous gravity displacement sedimentation. Sedimentation from traction. Eolian Processes: Sedimentation; traction and suspension.	3
	Glacial Processes: Glacial transport and sedimentation, Glacio-lacustrine and glacio-marine sedimentation. Gravitational Processes: Debris flows, Grain flows, Fluidized flows. Sedimentary Structures: Syn- and Post-depositional Sedimentary Structures. Paleocurrent Analysis. Sedimentary Environment: Definition, Classification, Facies, Facies Assemblage and Environmental models.	3
	Sediment to Rock	
Allochthonous Sediments	Conglomerates and Breccias: Classification and genesis. Mudrocks: Classification and genesis. Mudrock diagenesis.	3
	Sandstones: Classification, origin of sandstones: quartz arenites, arkoses, litharenites, and greywackes. Sandstone diagenesis and porosity evolution.	3
Autochthonous Sediments	Carbonate Sedimentary rocks: Components, Classification, Limestone diagenesis, and porosity evolution. Dolomite diagenesis.	3
	Authigenic Sedimentary rocks: Evaporites: Geological characteristics, carbonate-anhydrite cycle. Sedimentary Iron Ores: Dispersal of iron and formation of minerals, Oolitic iron ores, Precambrian banded Iron Formations. Sedimentary phosphate deposits: Nodular and Bedded phosphorites. Cherts and siliceous sediments: Bedded and nodular cherts, Non-marine cherts. Carbonaceous Rocks: Coals and coal series: Humic and Sapropelic coals, Coal formation and rank, Environment of coal deposition.	3

Textbooks

1. Selley, R.C. (2000). *Applied Sedimentology*, Second Edition, Academic Press, 543p.

2. Leeder, M.R. (1982). *Sedimentology: process and product*, Georg Allen and Unwin, London, 344p.
3. Boggs Jr. S. (2009). *Petrology of Sedimentary Rocks*, Second Edition. Cambridge University Press, 600p.
4. Freidman, G.M. and Sanders, J.E. (1978). *Principles of Sedimentology*, John Wiley and Sons, New York, 792p.
5. Collinson, J.D. and Thompson, D.M. (1994). *Sedimentary structures*, CBS, Delhi, 207p.
6. Tucker, M.E. (1981). *Sedimentary petrology: an Introduction*, Geoscience Texts, Vol. 3. Blackwell Sci. publications, 252p.
7. Pettihohn, F.J. (1975). *Sedimentary Rocks*, Harper and Row, New Yo5rk, 628p.
8. Pettijohn F. J. (1984). *Sedimentary Rocks*, 3rd edition, CBS Delhi, 628 p
9. Tamrakar, N.K. (2011). *Practical Sedimentology*, Bhrikuti Academic Publication, Kathmandu, 232p.
10. Tamrakar, N. K. (2011). *Practical Mineralogy*, CDGTU, Kirtipur, 184p
11. Morris, G. L. and Fan, J., (2010). *Reservoir Sedimentation Handbook*, McGraw-Hill, 805p.
12. Blatt, H. (1992). *Sedimentary Petrology*, second edition, W.H. Freeman and company, New York, 514p.

Reference Books

1. Folk, R.L. (1980). *Petrology of Sedimentary rocks*, Hemphill Publishing Company. Austin, Texas, 184p.
2. Pettijohn, F.J. Potter, P.E. Siever. R. (1987). *Sand and sandstones*, 2nd ed., Springer-Verlag; New York, Berlin, Heidelberg, London, Paris, Tokyo, 355p.
3. Lindholm, R. (1991). *A practical approach to sedimentology*, CBS Publishers and Distributors, Delhi, 176p.
4. Greensmith, J.T. (1978). *Petrology of the sedimentary rocks*, (sixth Edition). George Allen and UNWIN/Thomos Murby, London, Boston, Sydney.
5. Tamrakar, N.K. (2013). *Handbook of field geology with reference to the Siwaliks*, CDGTU, Kirtipur, Kathmandu, Nepal. 162p.
6. Reineck H.E. and Singh I.B. (1980). *Depositional Sedimentary Environments*, 2nd edition, Springer Verlag, 549p.

GEO.513: IGNEOUS PETROLOGY

Semester	I
Course Title	Igneous Petrology
Course Code	GEO.513
Full Marks	50
Pass Marks	25
Nature of the course	Theory
Credit	2 (30 hrs.)

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

General Objective: To provide an in-depth understanding of igneous rocks and their processes of formation and evolution.

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

-Magmatism

-Geodynamic relations of formation of different types of rocks

-Modern methods of study and analysis of igneous rocks.

(Total credit=2, FM=50, Teaching hours=30)

Title	Content	Teaching Hours
Igneous Petrogenesis		
Concepts of Thermodynamics and Kinetics	Heat flow in the Earth, Importance of thermodynamics in petrology, elementary concepts of thermodynamics, First and Second Laws of thermodynamics, Gibb's Free Energy for closed and open systems, chemical potential, Clausius-Clapeyron equation, thermodynamics of solutions (some basic concepts), application of thermodynamics to solutions, Limitations of classical thermodynamics, Activation energy, overstepping and metastable persistence	6
Silicate melts and volatile fluids in the magmatic system	Nature of magma, volatile fluids in melts, consequences of fluid exsolution from melts	2
Crystal-melt equilibria in magmatic system	Phase rule, stability (phase) diagram, melting of a pure mineral and polymorphism, phase relations in binary systems, phase relations in ternary system, sub solidus reaction in magmatic rocks	4
Chemical Dynamics of melts and crystals	The viscosity of melts, chemical diffusion, Interfacial energy and Crystallization, secondary overstepping processes, vesiculation, and fragmentation of magma	2
Fabric of magmatic rocks	Crystallinity and grain size, grain shape, inhomogeneous grains, fabrics related to secondary grain-boundary modification, exsolution, fragmentation of magma, consolidation of volcano-clastic rocks, anisotropic fabrics	2

Igneous Structures and Field Relationships	Extrusive, or volcanic processes, products, and landforms, pyroclastic deposits. Intrusive or plutonic processes and bodies, contact relationships of plutons, the process of magma rise and emplacement. Hydrothermal systems.	2
Chemical Petrology	Major and minor elements, analytical methods, Pearce Element Ratios (PERs). Graphical and mathematical models of magmatic evolution. Trace elements and isotopes. Models for solid melt processes: Batch melting, Rayleigh fractionation, spider diagrams, application of trace elements to igneous systems. Isotopes: Stable isotopes. Radioactive and Radiogenic isotopes,	2
Magma ascent	Movement of magma in the earth, sheet intrusions (dikes), diapirs, magma-emplacment in the crust (space problem)	2
Magma extrusion	Controlling factors for extrusion, effusion of basaltic lava, effusion of silicic lava, explosive eruptions, and other volcanoclastic deposits	2
Generation of magma	Melting of solid rocks, generation of basaltic magma, generation of granitic magma	2
Diversification of magma	Major and minor elements in the crust, variation diagrams, using variation diagrams to model magmatic evolution, Pearce Element Ratios (PER), closed-system magmatic differentiation, open-system diversification, differentiation in basaltic intrusions, origin of calc-alkaline differentiation trend	2
Magmatic Associations	Mid-Ocean Ridge Basalt (MORB), Ocean Island Basalt (OIB), Continental Flood Basalt, Ophiolites, Calc-alkaline rocks, A-type granites, S-type granites, I-type granites, Alkaline orphans (lamprophyres, kimberlites)	2

Textbooks

1. Philpott, A.R. and Ague, J.J. (2022). *Principles of Igneous and Metamorphic Petrology*, Cambridge University Press, 752p. <https://doi.org/10.1017/9781108631419>
2. Best, M. G. (2003). *Igneous and Metamorphic Petrology*, Second Edition, Blackwell Publishing, 729p.

Reference Books

1. Forst and Forst (2014). *Essentials of Igneous and Metamorphic Petrology*, First Edition, Cambridge University Press, 303p.
2. Winter, J.D. (2012). *Principles of Igneous and Metamorphic Petrology (second edition)*, PHI Learning Private Limited, New Delhi-110001, 702p.
3. Hyndman D.W. (1985). *Petrology of Igneous and Metamorphic Rocks*, McGraw Hill Inc., 786p.
4. Thorpe, R.S. and Brown, G.C. (1995). *The Field Description of Igneous Rocks*, John Wiley and Sons, 154p.
5. McBirney A.R. (1993). *Igneous Petrology*, Jones and Bartlett Publishers, Inc., 508p.
6. Hall, A. (1988). *Igneous Petrology*, ELBS, 573p.
7. Carmichael, I.S.E., Turner, F J., and Verhoogen, J. (1974). *Igneous Petrology*, McGraw Hill Inc., 739p.

GEO.514: METAMORPHIC PETROLOGY

Semester	I
Course Title	Metamorphic Petrology
Course Code	GEO.514
Full Marks	50
Pass Marks	25
Nature of the course	Theory
Credit	2 (30 hrs.)

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

General Objective: To provide an in-depth understanding of metamorphic rocks and their processes of formation and evolution.

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

- Metamorphism
- Geodynamic relations of formation and transformation of different types of rocks
- Modern methods of study and analysis of metamorphic rocks.

(Total credit=2, FM=50, Teaching hours=30)

Title	Content	Teaching Hours
Igneous Petrogenesis		
Introduction to Metamorphism	Limits of metamorphism, metamorphic agents and changes, types of metamorphism, progressive nature of metamorphism, types of protolith, P-T-t paths, grades, and zones. Some case studies of different types of metamorphisms.	4
Classification of Metamorphic Rocks	Foliated and lineated rocks, non-foliated and non-lineated rocks and high-strained rocks. Petrography and composition of metamorphic bodies.	2
Petrogenesis and Petro-fabrics of Metamorphic Rocks	Processes of deformation, recovery and recrystallization, textures, shear sense indicators, mechanism of tectonite development, gneissose structures, and layers, mineral growth, analysis of poly-deformed and poly-metamorphosed rocks. Crystallographically controlled inclusions, replacement textures, and reaction rims. Textural geo-chronology. Structural petrology.	4
Stable Mineral Assemblages	Equilibrium mineral assemblages. Phase rule in metamorphic system and common Chemographic diagrams. Chemical principles of metamorphism.	2
Metamorphic Facies and Facies Series	Metamorphic facies and facies series. Classification of three types of metamorphism based on P/T ratio. Facies of contact and regional metamorphism.	2

Metamorphic Reactions	Mineralogical and chemical aspects of metamorphic systems. Petrogenetic grids. Isograds. Reaction mechanisms. Principles of geothermo-barometry.	2
Metamorphism of Different Rocks	Metamorphism of ultramafic and mafic rocks, metamorphism of pelitic and calcareous rocks.	4
Metamorphic Fluids, Mass Transport, and Metasomatism	Metamorphic fluids. Role of fluids in metamorphism, Metasomatism, Changes associated with metasomatism. Metamorphic differentiation.	2
Field Relations of Metamorphic Bodies	Mylonite zones. Contact metamorphism and metasomatism. Burial metamorphic bodies. Regional metamorphism in orogenic belts. Paired metamorphic belts and plate tectonics. Serpentinites. Development of veins.	4
Methods of Study and Analysis of Metamorphic Rocks	Field observations and geological mapping. Mineral identification techniques. Chemical analysis. Thermobarometry. Isotopic dating. Fluid inclusion studies. Geochronology. Computer works.	4

Textbooks

1. Winter, J.D. (2012). *Principles of Igneous and Metamorphic Petrology (second edition)*, PHI Learning Private Limited, New Delhi-110001, 702p (original U.S. edition).
2. Best, M.G. (2003). *Igneous and Metamorphic Petrology*, Second Edition, Blackwell Publishing, 729p.

Reference Books

1. Turner and Verhoogen (1987). *Igneous and Metamorphic Petrology (second edition)*, CBS Publishers and Distributors, Delhi, 694p.
2. Forst and Forst (2014). *Essentials of Igneous and Metamorphic Petrology*, First Edition, Cambridge University Press, 303p.
3. Hyndman D.W. (1985). *Petrology of Igneous and Metamorphic Rocks*, McGraw Hill Inc., 786p.

GEO.515: STRUCTURAL GEOLOGY

Semester	I
Course Title	Structural Geology
Course Code	GEO.515
Full Marks	50
Pass Marks	25
Nature of the course	Theory
Credit	2 (30 hrs.)

Course Description: Structural geology deals with the architecture of the earth's crust and its componential parts.

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

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

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

The structural geology course also provides the concepts of stress and strain and concepts of microtectonics and structural analysis

Total credit=2, FM=50, Teaching hours=30)

Title	Content	Teaching Hours
Introduction	Introduction of structural geology and structural analysis, scope of structural geology, descriptive and kinematic analysis, concepts of structural analysis, limitations of structural analysis, homogeneous and inhomogeneous deformation.	4
Primary structures	Primary sedimentary structures and their significance in structural geology.	2
Secondary structures	Morphology, geometry, classification and mechanism, field identification criteria and geological and engineering geological significances of fold, faults, shear zones and joints. Concept of shear zone and mylonite.	10
Superimposed folding	Concept, environment and mechanism	2
Foliation and Lineation	Types, mechanism and structural geological significance of different types of foliation and lineation. Relationship between bedding and foliation.	2
Stress	Stress at a point. Stress on a plane. Principal planes of stress. Mohr circle. Types of stresses and Mohr circle configurations for them. Stress in two dimensions.	4

Strain	Definitions. Displacement vector, Displacement field, Displacement gradient. Homogeneous and inhomogeneous deformations. Simple shear and pure shear, finite and infinitesimal strain. Homogeneous deformation of straight line. Circle and ellipse. Changes in lengths and orientation of lines in different zones with strain ellipse and corresponding geological structures.	2
Microtectonics	Concept of microtectonics and its use in structural geology and other branches of geology.	2
Thin skin tectonics	: Introduction, Ramp and flat, Piggy back and overlap sequence, Imbricate fault, duplex, Nappe and Klippe, roof thrust and floor thrust, back thrust and its types, blind thrust, out of sequence thrust	2

Textbooks

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

Reference Books

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

GEO.516: STRATIGRAPHY AND MICROPALAEONTOLOGY

Semester	I
Course Title	Stratigraphy and Micropalaeontology
Course Code	GEO.516
Full Marks	50
Pass Marks	25
Nature of the course	Theory
Credit	2 (30 hrs.)

Course Description: This course is designed to acquire the knowledge about the basic principles of stratigraphy and microfossils contained in stratigraphic successions.

General Objectives: To provide the students knowledge of identification of rock successions and microfossils in solving geological problems.

Specific Objectives: To provide the students with in-depth knowledge and practical skills of Stratigraphy, microfossil identification and interpretation

(Total credit=2, FM=50, Teaching hours= 30)

Title	Content	Teaching Hours
Principles of Stratigraphy	Principles of stratigraphy; Laws of superposition and faunal succession; Geological time scale, Classification and nomenclature of stratigraphic units: lithostratigraphic, biostratigraphy and chronostratigraphic units; Sequence stratigraphy, International Stratigraphic Guide; Unconformity, Stratigraphic correlation, Index fossils.	6
Techniques of microfossil analysis	Types of fossils, Process of fossilization, Micropalaeontology: Importance and application of microfossils; Extraction methods in micropalaeontology; Microfossil in stratigraphy; Microfossils, stable isotopes and ocean atmosphere history; Microfossils as thermal metamorphic indicators, Palaeobiogeography, paleoecology and palaeoclimate; Co-existence theory, NLRs, Microfossil data analysis and representation.	4
Inorganic walled microfossils	Foraminifera, Radiolaria, Ostracods, Conodonts, Diatoms, Calcareous nannoplankton, Silicoflagellates and Chrysophytes.	8
Organic walled microfossils	Acritarchs, Dinoflagellates, Chitinozoa, Scolecodonts, Cladocera, Pollen and Spores	6
Microfossils in the Nepal Himalaya	Microfossils from the Nepal Himalaya, Palynological records from Tertiary and Quaternary succession in the Nepal Himalaya	4
Climatic events	Mass extinctions: Process and Events, Extinction in the Ice ages.	2

Text Books

1. Armstrong, H.A. and Brasier, M.D. (2005). *Microfossils*, London: Allen and Unwin, 305p.
2. Paudyal, K.N. (2017). *Study of Pollen and Spores*, CDGTU, Kirtipur, 196 p.

3. Paudyal, K.N. (2017). *Vegetation History of Nepal Himalaya*, CDGTU, Kirtipur, 108 p.
4. Boggs, S. (2006). *Principles of Sedimentology and Stratigraphy*, Pearson-Prentice Hall, 676p.

Reference Books

5. Brookfield, M.E. (2008). *Principles of Stratigraphy*, Blackwell Publishing Ltd, 340p.
6. Adolf, S., (2007). *Trace Fossil Analysis*, Springer Verlag, 238p.
7. Moore, P.D., Webb, J.A. and Collinson, M.E., (1994). *Pollen Analysis*, Oxford, 216p.

GEO.517: PRACTICAL OF GEO.511 and GEO.512

Semester	I
Course Title	Practical of Geo.511 and Geo.512
Course Code	GEO.517
Full Marks	50
Pass Marks	25
Nature of the course	Practical
Credit	2 (90 hrs.)

PART A: MINERALOGY

(1 credit, 45 hours)

Course Contents:

Lab 1: Classification of minerals

Lab 2: Study of physical properties of minerals

Lab 3: Identification of important silicate minerals in hand specimens.

Lab 4: Identification of important non-silicate minerals in hand specimens.

Lab 5: Polarising microscope set up and its handling.

Lab 6: Study of optical properties of minerals under plane polarized light.

Lab 7: Study of optical properties of minerals under crossed-nicols.

Lab 8: Study of optical properties of minerals under conoscopic setting.

Lab 9: Identification of essential rock-forming minerals under microscope (Quartz, alkali feldspar).

Lab 10: Identification of essential rock-forming minerals under microscope (perthite, plagioclase, microcline).

Lab 11: Identification of essential rock-forming minerals under microscope (Olivine and pyroxene).

Lab 11: Identification of essential rock-forming minerals under microscope (Hornblende, biotite, muscovite, sericite).

Lab 12: Identification of essential rock-forming minerals under microscope (Garnet, kyanite, Sillimanite).

Lab 13: Identification of essential rock-forming minerals under microscope (Chlorite, calcite).

Lab 14: Zoning and twinning in minerals under microscope.

Lab 15: Recalculation analysis of mineral formula.

Text and Reference Books:

1. Blackburn, W.H. and William, H.D. (1999). *Principles of Mineralogy*, Brown Publishers, 413p.
2. Shelley, D. (1985). *Optical Mineralogy*, Elsevier Science Ltd; 2nd edition, 352p.
3. Phillips, W.R. and Griffen, D.T. (1986). *Optical Mineralogy, The no-opaque minerals*, CBS Publisher and Distributaries, Delhi, 677p.
4. Tamrakar, N.K. (2011). *Practical Mineralogy*, CDGTU, Kirtipur, 184p.
5. Moorehouse, W.W. (1959). *The study of rocks in thin sections*, CBS Publishers and Distributors, 514 p.
6. Klein, C. and Hurlbut, Jr. (1985). *Manual of Mineralogy*, John Wiley and Sons, 596 p.
7. Paudel, L.P. (2011). *Study of Minerals and Rocks in Thin Sections*, GEOS, 102p.
8. Hutchison (1974). *Laboratory Methods in Petrography*, John Willey and Sons Inc. New York.
9. Zussam, J. (editor) (1977). *Physical Methods in Determinative Mineralogy*, Academic Press, 720 p.

PART B: SEDIMENTOLOGY

(1 credit, 45 hours)

Course Contents:

Lab 1: Grain size analysis of sediment sample

Lab 2: Representation, classification, statistical treatment and interpretation of grain size data.

Lab 3: Analysis of forms, sphericity and roundness of sediment, representation and interpretation.

Lab 4: Stereographic projection of fabric and structures, treatment of primary data.

Lab 5: Graphical representation of fabric and structure, analysis of vector data, treatment of data using statistical tool, and preparation of dispersal and palaeocurrent maps.

Lab 6: Study of hand specimens of Siliciclastic and autochthonous rocks: Description and nomenclature.

Lab 7: Study of thin sections of clastic rocks: description of textures, and textural classification.

Lab 8: Study of thin sections of clastic rocks: composition, classification, and using clastic petrographic data for provenance discrimination.

Lab 9: Study of thin-sections of carbonate rocks: description of textures, and textural classification

Lab 10: Study of thin-sections of carbonate rocks: composition, classification and nomenclature.

Text and Reference Books:

1. Boggs, Jr. S. (2009). *Petrology of Sedimentary Rocks*, Second Edition. Cambridge University Press. 600p.
2. Tamrakar, N.K. (2011). *Practical Sedimentology*, Bhrikuti Academic Publication, Kathmandu, 232p.
3. Tamrakar, N.K. (2011). *Practical Mineralogy*, CDGTU, Kirtipur, 184p
4. Collinson, J.D. and Thompson, D.B. (1994). *Sedimentary Structures*, CBS Delhi, 207p.
5. Adam, A.E., Mackenzie, W.S. and Guilford, C. (1988) *Atlas of Sedimentary Rocks under the Microscope*, ELSB, Longman Group, UK. 104p
6. Lindholm, R.C. (1991). *A Practical Approach to Sedimentology*, CBS Publishers and Distributors Delhi, 276 p.
7. Folk, R.L. (1980). *Petrology of Sedimentary Rock*, Hemphil Publishing Company, Austin Texas, 184p.
8. Freidman, G.M. and Sanders, J.E. (1978). *Introduction to Sedimentology*, Wiley, New York. 28
9. Pettijohn, F.J. (1984). *Sedimentary Rocks*, 3rd edition, CBS Delhi, 628p.

GEO.518: PRACTICAL OF GEO.513 and GEO.514

Semester	I
Course Title	Practical of Geo.513 and Geo.514
Course Code	GEO.518
Full Marks	50
Pass Marks	25
Nature of the course	Practical
Credit	2 (90 hrs.)

PART A: IGNEOUS PETROLOGY

(1 credit, 45 hours)

Course Contents:

Lab 1: Review of igneous rock classification, textures and structures.

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

Lab 3: Study of crystallization of magma in two and three component systems.

Lab 4: Preparation of chemical variation diagram and their interpretations.

Lab 5: Study of igneous rocks in handspecimens with emphasis on rock forming minerals, texture, structure, genesis and classification.

Lab 6: Study of igneous rocks in thin sections with emphasis on rock forming minerals, texture, structure, genesis and classification (Acidic/granitoid rocks).

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

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

Text and Reference Books:

1 Winter, J.D., (2012). *Learning Principles of Igneous and Metamorphic Petrology*, PHI Learning Private Limited, New Delhi, 702p.

2. Best, M.G., *Igneous and Metamorphic Petrology*, CBS Publisher and Distributors, Delhi, 630p.

3. Moorhouse, W.W, *The study of rocks in thin sections*, CBS Publisher and Distributors, Delhi, 514p.

4. Williams, H., Francis, J. Turner and Charles M. Gilbert. *Petrography: An introduction to the study of rocks in thin sections*, CBS Publishers and Distributors. Shahdara, Delhi-32, 514p.

5. Paudel, L.P., *Study of minerals and rocks in thin sections*, Geo-Science Innovations (P) Ltd., Kirtipur, Kathmandu, Nepal, 102p.

PART B: METAMORPHIC PETROLOGY

(1 credit, 45 hours)

Course Contents:

Lab 1: Study of metamorphic rocks in hand specimens with emphasis on mineral Assemblages, texture, structure, genesis, and metamorphic history.

Lab 2: Study of metamorphic rocks in hand specimens with emphasis on mineral assemblages, texture, structure, genesis, and metamorphic history.

Lab 3: Study of metamorphic rocks in thin sections with emphasis on mineral assemblages, texture, structure, genesis, and metamorphic history.

Lab 4: Study of metamorphic rocks in thin sections with emphasis on mineral assemblages, texture, structure, genesis, and metamorphic history.

Lab 5: Study of microstructures developed in metamorphic rocks under thin sections.

Lab. 6: Study of pressure-temperature diagrams and interpretation of metamorphic facies.

Lab. 7: Classification of metamorphic rocks using chemographic diagrams.

Text and Reference Books

- 1 Winter, J.D., (2012). *Learning Principles of Igneous and Metamorphic Petrology*, PHI Learning Private Limited, New Delhi, 702p.
2. Best, M.G., *Igneous and Metamorphic Petrology*, CBS Publisher and Distributors, Delhi, 630p.
3. Moorhouse, W.W, *The study of rocks in thin sections*, CBS Publisher and Distributors, Delhi, 514p.
4. Williams, H., Francis, J. Turner and Charles M. Gilbert. *Petrography: An introduction to the study of rocks in thin sections*, CBS Publishers and Distributors. Delhi, 514p.
5. Paudel, L.P., *Study of minerals and rocks in thin sections*, Geo-Science Innovations (P) Ltd., Kirtipur, Kathmandu, Nepal, 102p.

GEO.519: PRACTICAL OF GEO.515 and GEO.516

Semester	I
Course Title	Practical of Geo.515 and Geo.516
Course Code	GEO.519
Full Marks	50
Pass Marks	25
Nature of the course	Practical
Credit	2 (90 hrs.)

PART A: STRUCTURAL GEOLOGY

(1 credit, 45 hours)

Course Contents:

Lab 1: Contours and topography. Relationship between contours and contacts. Description of geomorphological and man-made features from topographic maps, construction of profiles.

Lab 2: Understanding the rule of V's, recognition of inliers, outliers, windows, klippe.

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

Lab 4: Study of geological maps and preparation of geological cross-sections of horizontal, inclined, vertical and folded beds.

Lab 5: Study of geological maps with unconformity, faults and dykes.

Lab 6: Determination of apparent and true thickness of beds.

Lab 7: Determination of through of faults.

Lab 8: Stereographic projection techniques

Lab 9: Three point problems

Lab 10: Geometrical and stereographic techniques for the determination of net slip, dip slip and strike slip along the fault planes

Lab 11: Busk construction of parallel folds

Text and reference books

1. Hobbs, B.E., Means, W.D., and Williams, P.F. (1976). *An Outline of Structural Geology*, John Wiley and Sons, 571 p.
2. Ramsay, J.G. (1967). *Folding and Fracturing of Rocks*, McGraw Hill Inc., 568 p.
3. Passchier, C.W. and Trouw R.A.J. (2003). *Micro-tectonics*, Springer, 253 p.
4. Ramsay, J.G. and Huber, M.I. (1983). *The Techniques of Modern Structural Geology*, Volume 1: Strain Analysis, Academic Press, 307 p.
5. Bayly, B. (1991). *Mechanics in Structural Geology*, Springer-Verlag, 253 p
6. Johnson A.M. (1977). *Styles of Folding*, Elsevier Scientific Publishing Company, 406 p.
7. McClay, K.R. (1987). *The Mapping of Geological Structures*, John Wiley and Sons Inc., 161 p.
8. Ragan D.M. (1985). *Structural Geology, An Introduction to Geometrical Techniques*, 3rd edition, John Wiley and Sons Inc., 393 p.
9. Means W.D. (1985). *Stress and Strain Basic concepts of continuum mechanics for geologists*, Springer-Verlag New York, 339 p.
10. Davis G.H. and Reynolds S.J. (1996). *Structural Geology of rocks and regions*, John Wiley and Sons Inc., 776 p.

PART B: STRATIGRAPHY AND MICROPALAEONTOLOGY

(1 Credit, 45 hours)

Course Contents

- Lab 1: Geological time scale-major climatic and biotic events
- Lab 2: Paleogeography and Paleoclimate of the Earth
- Lab 3: Process of fossilization
- Lab 4: Index fossils through geological time
- Lab 5: Extraction of microfossils
- Lab 6: Study of Foraminifera and Raiolaria
- Lab 7: Study of Ostracodes and Conodonts
- Lab 8: Study of Pollen and Spores, Diatoms and Dinoflagellates
- Lab 9: Microfossils from the Nepal Himalaya
- Lab 10: Interpretation of microfossils data, climate reconstruction

Text and reference books

1. Armstrong, H.A. and Brasier, M.D. (2005). *Microfossils*, London: Allen and Unwin, 305p.
2. Paudyal, K.N. (2017). *Study of Pollen and Spores*, CDGTU, Kirtipur, 196 p.
3. Paudyal, K.N. (2017). *Vegetation History of Nepal Himalaya*, CDGTU, Kirtipur, 108 p.
4. Boggs, S. (2006). *Principles of Sedimentology and Stratigraphy*, Pearson-Prentice Hall, 676p.
5. Brookfield, M.E. (2008). *Principles of Stratigraphy*, Blackwell Publishing Ltd, 340p.
6. Adolf, S., (2007). *Trace Fossil Analysis*, Springer Verlag, 238p.
7. Moore, P.D., Webb, J.A. and Collinson, M.E., (1994). *Pollen Analysis*, Oxford, 216p.

GEO.520: FIELD WORK

Semester:	I
Course Title	Field work
Course Code	GEO.520
Full Marks	100
Pass Marks	50
Nature of the course	Practical
Credit	4 (4 weeks)

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

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

Specific objective: To provide the students with the techniques of

- Describing rock outcrop.
- Mapping of rock outcrop,
- Interpretation of rocks texture and structure palaeocurrent, sedimentary structure, folds and faults, and
- Preparation of geological maps, stratigraphic columns and geological cross-sections.
- Give the knowledge of different tectonic units of the Nepal Himalaya.

Field work duration: The field work will carry a total of 28 days. One credit of field work will have 70 hours of teaching per week. One teacher will be assigned per 10 students in the field.

Course Contents

Location: The fieldwork will be carried out for two weeks in the Sub-Himalaya and another two weeks in the Lesser Himalaya of Makawanpur, Bara, Tanahu, Gorkha and Dhading Districts. The location may vary depending upon the criteria set by the Department and situation in the field sites.

Fieldwork in the Sub-Himalaya (14 days; 2 credits)	
Introduction: Reading of topographical and geological maps of the area, identification of main lithological, stratigraphic and structural features of the area, learn techniques of stratigraphic and sedimentologic surface data acquisition, learn to measure various sedimentary structures and geological structures, and study of processes and origin of rocks, Identification, description and nomenclature of rocks, Graphical and statistical treatment of sedimentological scalar and vector data	
Title	Contents
Preparatory works	Reading of topographical and geological maps of the area, Review of literatures, Field orientation and Regulations.
Mapping:	Geological traverse. Recording field data. Measuring sedimentary structures and bed structures. Preparation of graphic logs of large scale. Geological Route Mapping. Columnar sectioning from the route map. Introduction to modern fluvial environment and mapping of quarternary alluvial fan, Mapping of lithological boundaries, tectonic contacts and other structural features (folds, faults, joints, foliation, bedding, etc.). Preparation of the geological maps and cross-sections in 1:25,000 scales.

Interpretation:	Interpretation of the data on the basis of measured attitudes of beds. Use of stereographic projection in palaeocurrent analysis and statistical analysis. Interpretation of sedimentary structures and processes of sedimentation. Use of various graphical plots to interpret composition and shape of sediment grains. Interpretation on sediment sourcing. Interpretation of environments of deposition of sedimentary rocks. Interpretation of geological structures.
Field report:	The students need to prepare sketches, maps, and field notebooks containing all the relevant information. The field report includes chapters on regional setting, literature review, lithostratigraphy, environment of deposition, and structural interpretation of the area on geological maps and cross-sections. Apart from the report, the students will collect relevant rocks and fossil samples.

Fieldwork in the Lesser Himalaya (14 days; 2 credits)	
Introduction:	Study of topographical and geological maps of the area, identification of main lithological, stratigraphic and structural features of the area and study of contacts of various rock units.
Title	Contents
Preparatory works	Reading of topographical and geological maps of the area, Review of literatures, Field orientation and Regulations.
Mapping:	Preparation of route maps and columnar sections of the important units. Mapping of lithological boundaries, tectonic contacts and other structural features (folds, faults). Measurement and analysis of joints, foliation, lineation, bedding, etc. Preparation of the geological maps in 1:25,000 scales. Prepare a metamorphic zonation map of the area based on index minerals. Identify the possible mineral resources in the area.
Interpretation:	Preparation of geological cross-section, analysis of structural. Interpret the environment of deposition, tectonic history and finally establishment of the geological history of the area.
Field report:	The field report includes chapter on regional setting, previous works, lithology, stratigraphy and environment of deposition, structural interpretation of the area and geological maps and cross-sections. Apart from the report, the students will collect relevant rocks and fossil samples. The students prepare drawings, maps, and field notebooks containing all the relevant information. The content of the field report may vary depending upon the actual data gathered in the field and their interpretation.

Text and reference books

1. Thrope R.S. and Brown G.C. (1995). *The Field Description of Igneous Rocks*, John Wiley and 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. Paudel, L.P., (2012). *Handbook of Field Geology*, Geo-Science Innovations (P) Ltd., 134p.
6. Tamrakar, N.K. (2013). *Handbook of Field Geology with reference to the Siwaliks*, CDGTU,

Kirtipur, 162p.

7. Tamrakar, N. K. (2011). *Practical Sedimentology*, Bhrikuti Academic Publication, Kathmandu, 232p.

8. McClay, K.R. (1987). *The Mapping of Geological Structures*, John Wiley and Sons Inc., 161 p

10. Gansser, A. (1964). *Geology of the Himalayas*, John Wiley and Sons Inc.

11. Journal of Nepal Geological Society (Various issues)

12. Bulletin of Department of Geology (Various issues)

SEMESTER II

Semesters	SN	Course code	Course name	Credits	Marks
Second	1	GEO.551	Geology of the Himalayas	2	50
	2	GEO.552	Quaternary Geology and Palaeoclimate	2	50
	3	GEO.553	Environmental Sedimentology	2	50
	4	GEO.554	Remote Sensing and GIS	2	50
	5	GEO.555	Geology of Mineral Deposits	2	50
	6	GEO.556	Exploration Geophysics	2	50
	7	GEO.557	Practical of GEO.551 and GEO.552	2	50
	8	GEO.558	Practical of GEO.553 and GEO.554	2	50
	9	GEO.559	Practical of GEO.555 and GEO.556	2	50
			Total	18	450

GEO.551: GEOLOGY OF THE HIMALAYAS

Semester	II
Course Title	Geology of the Himalayas
Course Code	GEO.551
Full Marks	50
Pass Marks	25
Nature of the course	Theory
Credit	2 (30 hrs.)

Course Description and General Objectives: To provide in-depth knowledge on Himalayan Geology and its current understandings. Himalayan geology covers the stratigraphic, tectonic, structural, magmatic, metamorphic and sedimentary geological as well as palaeontological and economic geological aspects of the Himalaya.

Specific objectives:

To provide the students in-depth knowledge of

- various stratigraphic sub-divisions of the Himalaya,
- tectonic and structural set up of the Himalaya and its relation with the adjacent regions
- comparison and correlation of various rock units
- fossils as well as economic rocks and minerals of Nepal
- evolutionary history of the Himalaya.

(Total Credit: 2; Full Marks: 50)

Title	Content	Teaching hours
<i>Introduction and broader framework of the Nepal Himalaya</i>	Basic definitions: Himalayan Range, Himalayan orogen, and Himalayan tectonic system, Relation of the Himalaya with other mountain chains of the region. Geology of the Peninsular India with special reference to Delhi. Vindhians, Gondwanas, and salt Range. Major sub-divisions of the Himalaya: Geomorphic and tectonic sub-divisions. Brief account of the Punjab, Kumaun, Skkim and Bhutan Himalayas.	4
<i>Stratigraphy of the Nepal Himalaya</i>	Precambrian successions of Higher and Lesser Himalayas, Mesozoic successions of Tethys and Lesser Himalayas, Tertiary successions of Lesser and Sub-Himalayan zones. Quaternary successions of intermountain basins of Lesser and Higher Himalayas. Correlation of reference sections from Nepal and adjacent countries. Geology of the Terai region.	6
<i>Major Geological Structures</i>	Indus–Tsangpo Suture zone, Himalayan syntaxes, Tethyan Himalayan fold-and-thrust belt, Great counter thrust and north-Himalayan antiform, South Tibetan Detachment System and other major extensional faults, Main Central Thrust, MCT lateral ramp and western extension, southward extension of the MCT (Lesser Himalayan nappes), relationship between MCT-I and MCT-II. Age and slip on the STDS and MCT. Out-of-sequence thrusts and uplifts of the Himalaya. Neogene north-trending rifts. Exhumation of the Himalaya.	2
<i>Metamorphism</i>	Metamorphism in the Higher Himalaya and the MCT zone, low-grade metamorphism in the Lesser and Tethys Himalayas. Inverted metamorphism and its origin. Thermobarometric and geochronological data. <i>Models for Himalayan inverted</i>	4

	<i>metamorphism</i> : Kinematic models, thermal models, coupled thermal and mechanical models.	
<i>Magmatism</i>	Precambrian mafic rocks, Permian basalts, Precambrian granitoids, Early Palaeozoic granites, Tertiary granites, geochemical and isotopic characteristics, geochronological data, petrogenesis and tectonic significance of magmatic rocks. Models for Cenozoic Himalayan anatexis.	2
<i>Fossil records</i>	Vertebrate fossils, invertebrate fossils, pollens and other microfossils.	2
<i>Economic geological aspects</i>	Industrial rocks and minerals, ore mineral deposits, gems and semi-precious stones, fossil fuels.	4
<i>Seismotectonics</i>	Seismotectonics of the Himalaya, seismicity in the Nepal Himalaya, historic earthquakes, recent microseismicity, active faults and neotectonic activity, Paleoseismicity of the Himalaya, seismic hazard scenario, seismic network of Nepal.	2
<i>Geological evolution of the Himalaya</i>	Models of evolution of the Himalaya. The original configuration of the Himalaya prior to Cenozoic deformation: single passive continental margin model, separate basin model, accreted terrane model, carboniferous-extension model. Kinematic models for emplacement of the Higher Himalayan crystalline: Wedge extrusion and channel flow, continental subduction, MCT reactivation from Palaeozoic suture. Geological evolution of Himalaya during Precambrian, Palaeozoic, Mesozoic and Cenozoic eras.	2
<i>Recent Researches in the Nepal Himalaya</i>	Review of research articles on recent researches in various aspects of the Nepal Himalaya.	2

Text Books

1. Dhital, M.R. (2015). *Geology of the Nepal Himalaya: Regional Perspective of the Classic Collided Orogen*. Springer, 498p.
2. Gansser, A. (1964). *Geology of Himalaya*. John Wiley and Sons Inc.
3. Valdiya, K.S. (1998). *Dynamic Himalaya*. University Press, New Delhi.
4. Mascle, G., Pecher, A., Guillot, S., Rai, S.M., Gajurel, A. (2013). *Himalaya-Tibet collision*. Nepal Geological Society.

Reference Books

1. Saklani, P.S. (Ed.). (2007). *Himalaya: Geological Aspects*, Satish Serial Publishing House, India.
2. Yin, A. and Harrison, T.M. (eds.) 1996. *The Tectonic Evolution of Asia*, Cambridge University Press.
3. Shackleton, R.M., Dewey, J.F. and Windley, B.F. (eds.) (1988). *Tectonic evolution and Himalaya and Tibet*, Cambridge University Press.
4. Research articles in various issues of the journal of Nepal Geological Society (NGS), Stratigraphic Association of Nepal (SAN), Bulletin of the Department of Geology, TU, and other International earth science journals.

GEO.552: QUATERNARY GEOLOGY AND PALAEOCLIMATE

Semester	II
Course Title	Quaternary Geology and Palaeoclimate
Course Code	GEO.552
Full Marks	50
Pass Marks	25
Nature of the course	Theory
Credit	2 (30hrs.)

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.

Specific Objectives: To provide the students with in-depth knowledge and practical skills working in Quaternary sequence and climatic information derived from them.

(Total credit=2, FM=50, Teaching hours= 30)

Title	Contents	Teaching hrs.
The Quaternary Period	General characteristics of the Quaternary Period, Holocene and Anthropocene	2
Classical Models	The Alpine Model, Northern Europe, British Isles, Central North America and East Africa.	6
The Oceanic Record	Sediments of the Pelagic Environment, Oxygen Isotope Analysis, Oxygen Isotope Stratigraphy	4
Classification	The Quaternary and pre Quaternary, Data presentation: climatic curves, Stratigraphic classification, Chronostratigraphic classification, Last Interglacial, Last Glaciation, Holocene.	4
Geochronometric Dating	Radiocarbon dating, Uranium series Disequilibrium Dating Methods, Potassium- Argon and Argon40/Argon39 Dating, Fission Track Dating, Magnetostratigraphy, Amino Acid Diagenesis, Glacial Varves, Nonglacial Annual Deposits, Dendrochronology. Quaternary Climate change.	2
The Fossil Record	Pollen Analysis, Mammalian Faunas, Coleoptera, Hominids, Deep Sea Biostratigraphy	2
Sea Level	Factors determining sea level, Pleistocene sea level, Late-glacial and Holocene sea levels.	2
Glaciation	Models of Glaciation and Deglaciation, Pleistocene Depositional Sequences and Landforms.	2
Non-glacial Environments	Tephrochronology, Palaeosols, Periglacial Environments, Low Latitude Environments and Fluvial Lakes.	2
Quaternary Deposits of Nepal	Quaternary Deposits of Nepal: Kathmandu, Pokhara and Thakkhola Basins, Dun Valleys, Indo-gangetic Plain, Flora and Fauna from the Quaternary Deposits of Nepal and their climatic significance.	4

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.
4. Paudyal, K.N. (2017). *Vegetation History of Nepal Himalaya*, CDGTU, Kirtipur, First edition, 108 p.

Geo. 553: ENVIRONMENTAL SEDIMENTOLOGY

Semester	II
Course Title	Environmental Sedimentology
Course Code	GEO.553
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 dynamics 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

(Total credit=2, FM=50, Teaching hours=30)

Title	Contents	Teaching hrs
Mountain Environments	Characteristics. Definition and classification. Mountain sediment cascade. Sediment 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.	3
	Glacial system: Major environments. Physical processes of ice flow. Glacial flow, basal lubrication and surges. Sediment transport, erosion and deposition by flowing ice. Glacial environment and sediments. <i>Paraglacial environment:</i> Ice-produced glacial erosion and depositional sediments. <i>Proglacial environment</i> : Glaciofluvial processes on land and within the ice-front. Glacimarine environments. Glacilacustrine environments. <i>Periglacial environment.</i>	3
	Glacial system and environmental change: fluvio-glacial sedimentation and glacier outburst floods. Slope movements. Impacts on upland sediment systems. Management and Remediation.	
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, Classification of fluvial system.	
	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 channel fills. Braid bar deposits. Sedimentation models for fine-grained braid bar deposits.	3
	Meandering rivers: channel processes ; classical point-bar model, channel cut-offs, overbank sedimentation and environments. Areas beyond river influence. Anastomosed River system : morphology.	3

	<p>Longitudinal variation of anastomosis. Sedimentation and facies model.</p> <p>Sediment sources and accumulation processes: Characteristics of fluvial sediments, Sediment provenance. Controls on sediment supply, transport and accumulation.</p> <p>Processes and impacts of anthropogenic activities : Anthropogenic impacts on rate of sedimentation. Agriculture, deforestation and afforestation. Mining. River regulation and channelization. Urbanization.</p> <p>Sediment as sink for contaminants: Sediment contaminants. Sediment-borne contaminant transport. Deposition of sediment-borne contaminants. Contaminant remobilization.</p> <p>Management and restoration of fluvial systems : Impacts of climate change. Impacts of increased anthropogenic disturbance. Other impacts. Remediation.</p>	3
Lake Environments	<p>Lakes and sedimentological environments : Lake types and classification. Controls on lake form. 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.</p>	3
	<p>Controls on lake sediment transport and accumulation: Transport, sedimentation and resuspension. Bottom dynamic conditions in lakes. Post-depositional processes.</p> <p>Processes and impacts of disturbance events : Storms and mass movements. Lake-level fluctuations. Lake sediment pollution. Toxicity of chemical water and lake sediment pollutants. Climate change impact on lakes.</p>	3
Arid Environments	<p>Definition and arid environments. Causes of aridity : Climate. Tectonics. Anthropogenic agents. Sediment sources and transport : Significance of weathering in arid regions : Insolation. Moisture. Salt weathering. Zone of net erosion : Slopes. Exposed lake sediment.</p>	3
	<p>Sediment transport by water : Flow characteristics of ephemeral channels. Sediment transport by wind : Transport zones. Transport processes.</p> <p>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.</p>	
	<p>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.</p>	3
Deltaic and Estuarine Environments	<p>Introduction. Classification. Sediment sources and sedimentation processes in deltas and estuaries. Processes and impacts of natural and anthropogenic change in deltas and estuaries. Managing for prevention of environmental change.</p>	
Coastal Environments	<p>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.</p>	3
	<p>Tropical coastal environments: Distribution and occurrence of coral reefs and mangroves. Sources and characteristics of coral reef</p>	

	sediments. Reef sediment transport and accumulation. Sources and characteristics of mangrove sediments. Management and remediation of coral reef and mangrove sediments.	
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Text Books

1. Leeder, M. (2011). *Sedimentology and Sedimentary Basins from 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.
8. Tamrakar, N. K. (2011). *Geo-environmental Hazards*. Central Department of Geology, Kirtipur, 170p.
9. 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.
10. Tamrakar, N.K. and Acharya, K.K. (2012). *Environmental Earth Science*. Dikshant Prakashan, Kirtipur, Nepal. 398p.
11. Shrestha, A. B. (2008). *Resource manual on flash flood risk management, module 2: nonstructural measure*, ICIMOD, 89p

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.

Geo.554: REMOTE SENSING AND GIS

Semester	II
Course Title	Remote Sensing and GIS
Course Code	GEO.554
Credits	2
Teaching hours	30 hrs.
Full Marks	50
Pass Marks	25
Nature of the course	Theory

Course Description: The course of Remote Sensing and GIS gives the necessary knowledge and skills of remote sensing inputs necessary for geological investigation and evaluation at regional and local scale. The course provides essentials of remote sensing and GIS tools and techniques applicable in various geological investigation required for core and applied fields.

General Objective

To give in-depth knowledge and practical skills on analysis and interpretation of remote sensing data for various geological applications.

Specific Objective

To make the students able to

- Remote sensing data processing and interpretation
- Their use in geology, engineering geology, hydrogeology and mineral prospecting,
- Data preparation, analysis and map production in GIS.

(Total credit=2, FM=50, Teaching hours=30)

Title	Content	Teaching Hour(s)
Introduction	Development in aerial and space photography, Advantages and limitations of photogeological techniques; Energy source and radiation principles. Energy interactions in the atmosphere and with earth surface features. Data acquisition and interpretation	3
Photo/image interpretation	Elements of image/photo-interpretations of geotechnical elements such as drainage, soil, landforms and vegetation, convergence of evidence	2
Aerial photography	Photographic flight mission and layout, Type of aerial photography, stereoscopy and vertical exaggeration.	2
Geometric characteristics of aerial photographs	Mosaic construction, 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, determination of geological data	2
Earth resource satellites operating in the optical spectrum	Earth resource satellites operating in the optical spectrum. Multispectral, thermal and hyperspectral scanning. Landsat satellite program overview, Orbit characteristics and sensors of different Landsat missions. Landsat image interpretation. SPOT Satellite Program and other major satellite missions aimed for earth observing system.	2
Multispectral, thermal, and	Across- track and Along-track multispectral scanning. Thermal, and hyperspectral scanning. Thermal radiation principles.	3

hyperspectral scanning	Temperature mapping with thermal scanner data. Interpreting thermal scanner imagery.	
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
New Technologies	Space-borne Synthetic Aperture Radar (SAR) interferometry (InSAR); Ground based interferometry (GB-InSAR); LiDAR (Light Detection And Ranging, ground- and air-borne), known also as Airborne Laser Scanner (ALS) and; Terrestrial Laser Scanner (TLS); Unmanned Aerial Vehicles (UAV) or drones- Interpretation of SLAR imagery. Elements of passive microwave sensing. Passive microwave sensors.	2
GPS and GPS 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, Concept of data model; vector and raster data model; topology; TIN data model. Data import and export, GIS maps and its application.	2
Coordinate Systems and Map projections	Introduction, geometric earth models, Geodetic datum, requirement of map projection, properties of map projection, projection surfaces and projection family, Projection systems and, Nepalese projection system	1
GIS data sources	Data feeds to GIS and their characteristics (maps, GPS, images, databases; commercial data etc.), data formats; data quality; metadata. Input of spatial data, Modes of data input, Rasterization and vectorization, Map preparation and the digitizing, Remote Sensing- Special Raster Data Input, Integrating different data sources, External Databases. Storage of GIS database, editing, data error and error propagation	3
Spatial analysis	Conceptual framework, spatial data models, Geoprocessing, Spatial analysis (Geo spatial and Spatial Analyst), 3D Analyst, raster and vector-based GIS analysis; raster and vector analysis; Map overlay; map calculations; statistics; integrated spatial analysis.	3

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.

Reference Books

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.555 GEOLOGY OF MINERAL DEPOSITS

Semester	II
Course Title	Geology of Mineral Deposits
Course Code	GEO.555
Full Marks	50
Pass Marks	25
Nature of the course	Theory
Credit	2 (30 hrs.)

Course Description: The course deals with the principles and processes of formation of mineral Deposits and their industrial use.

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 geological control, and the mineralization process of mineral deposits and specification criteria of industrial rocks and minerals.

(Total credit=2, FM=50, Teaching hours=30)

Title	Content	Teaching hours
Conceptual Background and Fundamental Principles of Mineralization	Introduction to mineral resources, specialties of mineral resources, history of use of mineral resources (stone age, bronze age, iron age, modern age), global distribution of mineral resources. metallogenic provinces and epochs, stages of ore development, the genesis of mineral deposits, the morphology of ore bodies, ore structures, and textures, ore-bearing fluids, processes and mechanism of migration, Wall rock alteration, and Gangue minerals. Geothermometry, and geobarometry. Paragenetic sequence, zoning, and dating of ore deposits. Isotope studies.	4
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, the composition of igneous rocks vs. mineral deposits, sources of material of minerals deposits, methods of studying deposits, ore genesis. Classification of ore deposits.	3
Geological Control of Mineralization	Structural, stratigraphic, and host rock properties. Mineralization in the light of plate tectonics.	2
Types and Genesis of Mineral Deposits	Magmatic deposits, pegmatite deposits, carbonatite deposits, skarn deposits, albite-greisen deposits, hydrothermal deposits, pyritic deposits, deposits of weathering, placer deposits, sedimentary deposits, metamorphogenic deposits, epigenetic deposits of doubtful igneous connection, deposits related to solution-remobilization.	6
Gemstones	Identification of natural gemstones, precious and semi-precious stones, and synthetic gems. Approaches of gemstone classification. Cutting and polishing of gemstones, religious and economic values, gemstone mines, and industries in Nepal.	3

Petroleum, Natural Gas and Coal	Origin and generation of petroleum and natural gas, trapping of oil and gas, types of oil, and the present status of oil and natural gas exploration in Nepal. Coal: Origin and formation of coal deposits, classification of coal, calorific value, coal prospects/deposits, and mines in Nepal.	3
Industrial Rocks and Minerals	Metallic ore minerals, non-metallic minerals, dimension stones, fertilizer minerals, Silica sand, and construction materials. Uses of igneous, sedimentary, and metamorphic rocks in the industries. Specifications: criteria and guidelines.	3
Mineral Resources of Nepal	Study of geological controls, mineralization process, status and specification and prospects of mineral deposits in Nepal Himalaya.	6

Textbooks

1. Evans, A.M. (1993). *Ore Geology and Industrial Minerals, An Introduction* (third edition); Blackwell Scientific Publications, 379p.
2. Guilbert and Park (2007). *The Geology of Ore Deposits*. CBS Publisher and Distributors Pvt. Ltd. New Delhi, 985p
3. Smirnov, V.I. (1989). *Geology of Mineral Deposits*. Nem Chand and Brothers, 520p.
4. Sah and Paudyal (2023). *Geology of Mineral Resources*. Publication: Stratigraphic Association of Nepal (SAN), 303p.
5. ESCAP (1993). *Atlas of Mineral Resources of Nepal*, vol. 9, UN publication.

References Books

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.
5. Journals of Nepal Geological Society and Bulletin of Department of Geology, Tribhuvan University, Kirtipur, Kathmandu.

Geo.556: EXPLORATION GEOPHYSICS

Semester	II
Course Title	Exploration Geophysics
Course Code	GEO.556
Full Marks	50
Pass Marks	25
Nature of the course	Theory
Credit	2 (30 hrs.)

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.

(Total credit=2, FM=50, Teaching hours= 30)

Title	Content	Teaching hours
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 forward 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-masse 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	4

	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	
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 Books

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.

GEO.557: PRACTICAL OF GEO.551 AND GEO.552

Semester	II
Course Title	Practical of Geo.551 and Geo.552
Course Code	GEO.557
Full Marks	50
Pass Marks	25
Nature of the course	Practical
Credit	2 (90 hrs.)

PART A: GEOLOGY OF THE HIMALAYA

(1 credit, 45 hours)

Course Contents:

- Lab 1: Preparation of tectonic map of the Himalaya with description of major tectonic divisions.
- Lab 2: Preparation of the Geological map and schematic cross section of Nepal and describe major geological features.
- Lab 3: Study of the Lithostratigraphy of the Siwaliks: Prepare lithostratigraphic columns of major sections of the Siwaliks from Nepal and make correlation chart.
- Lab 4: Study of the Lithostratigraphy of the Lesser Himalaya: Prepare lithostratigraphy of major sections of the Lesser Himalaya from Nepal and correlate them.
- Lab 5: Study of the Lithostratigraphy of the Higher Himalaya: Prepare lithostratigraphy of major sections of the Lesser Himalaya from Nepal and correlate them.
- Lab 6: Study of the Lithostratigraphy of the Tethys Himalaya: Prepare lithostratigraphy of major sections of the Lesser Himalaya from Nepal and correlate them.
- Lab 7: Study of lithostratigraphy of the Kathmandu valley sediments, Thakkhola sediments and Pokhara valley sediments.
- Lab 8: Preparation of cross-section of Nepal showing metamorphic zones. Preparation of models of inverted metamorphism and describe them.
- Lab 9: Analysis of chemical compositions of garnets, muscovite and hornblende from the MCT zone and their interpretation.
- Lab 10: Preparation of map of Nepal showing distribution of granites. Describe major features of the granites (field relation, mineralogy, texture, chemistry and ages).
- Lab 11: Study of plant fossils of Nepal.
- Lab 12: Study of vertebrate fossils of Nepal.
- Lab 13: Study of invertebrate fossils of Nepal.
- Lab 14: Preparation of mineral resource distribution map of Nepal.
- Lab 15: Study of major metallic and non-metallic mines of Nepal.

Text and Reference Books

1. Dhital, M.R. (2015). *Geology of the Nepal Himalaya: Regional Perspective of the Classic Collided Orogen*. Springer, 498p.
2. Gansser, A. (1964). *Geology of Himalaya*. John Wiley and Sons Inc.
3. Valdiya, K.S. (1998). *Dynamic Himalaya*. University Press, New Delhi.
4. Mascle, G., Pecher, A., Guillot, S., Rai, S.M., Gajurel, A., (2013). *Himalaya-Tibet collision*. Nepal Geological Society.
5. Research articles in various issues of the journal of Nepal Geological Society (NGS), Stratigraphic Association of Nepal (SAN), Bulletin of the Department of Geology, TU, and other International earth science journals.
6. Geological Maps published by Department of Mines and Geology and Central Department of Geology.

PART B: QUATERNARY GEOLOGY AND PALAEOCLIMATE

(1 credit, 45 hours)

Course Contents:

- Lab 1: Classification models of Quaternary Deposits in Europe
- Lab 2: Classification models of Quaternary Deposits in North America
- Lab 3: Chronostratigraphic scale of Quaternary Period
- Lab 4: Study of Quaternary deposits from the Kathmandu Basin.
- Lab 5: Study of Quaternary deposits from the Pokhara Basin.
- Lab 6: Study of Quaternary deposits from the Thakkhola Basin.
- Lab 7: Study of Quaternary deposits from the Indo-Gangetic Plain.
- Lab 8: Preparation of Quaternary glaciation map from different parts of the world.
- Lab 9-10: Vertebrate fossils from the Quaternary deposits of Nepal
- Lab 11-12: Microfossils (Pollen and Diatoms) from the Quaternary deposits of Nepal
- Lab 13-14: Plant fossils from the Quaternary deposits of Nepal
- Lab 15: Interpretation of fossil data for Palaeoclimate interpretation.

Textbooks

1. Bowen, D.Q. (1978). *Quaternary Geology: A Stratigraphic Framework for Multidisciplinary Work*. Pergamon Press, 240 p.
2. Paudyal, K.N. (2017). *Vegetation History of the Nepal Himalaya*, CDGTU, Kirtipur, 108 p.

GEO.558: PRACTICAL OF GEO.553 AND GEO.554

Semester	II
Course Title	Practical of Geo.553 and Geo.554
Course Code	GEO.558
Full Marks	50
Pass Marks	25
Nature of the course	Practical
Credit	2 (90 hrs.)

Part A: ENVIRONMENTAL SEDIMENTOLOGY

(1 credit, 45 hours)

Course Contents:

- 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: Empirical estimation of debris flow velocity.
- Lab 5 : Analysis of river discharge using a flow resistance equation and hydraulic parameters.
- Lab 6: Estimation of bank erosion loss using annual recession data
- Lab 7: Construction of velocity distribution in stream channel and discharge calculation using area-velocity method.
- Lab 8: Incipience of sediments using shear stress criteria. Computation of unit bedload discharge using various approaches.
- Lab 9: Determining suspended sediment concentration from samples from rivers.
- Lab 10: Plotting of sediment rating curve using given data on discharge and suspended sediment concentration of the Himalayan Rivers from gauge stations.

Text Books

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.
6. Tamrakar, N.K. (2011). *Geo-environmental Hazards*. Central Department of Geology, Kirtipur, 170p.
7. Tamrakar, N.K. and Acharya, K.K. (2012). *Environmental Earth Science*. Dikshant Prakashan, Kirtipur, Nepal. 398p.

Reference Books

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.

Part B: REMOTE SENSING AND GIS

(1 credit, 45 hours)

Course Contents:

- Lab 1: Determination of scale of aerial photo with the help of topographic map; stereo-viewing in stereoscope
- Lab 2: Practicing elements of photo interpretation
- Lab 3: Interpretation of aerial photo and satellite image: Extraction of geological information (lithology, structure 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, vector 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.

Reference Books

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.559: PRACTICAL OF GEO.555 AND GEO.556

Semester	II
Course Title	Practical of Geo.555 and Geo.556
Course Code	GEO.559
Full Marks	50
Pass Marks	25
Nature of the course	Practical
Credit	2 (90 hrs.)

Part A: GEOLOGY OF MINERAL DEPOSITS

(1 credit, 45 hours)

Course Contents:

- Lab 1: Study and identification of non-metallic minerals in hand specimens with reference to texture, structure, association, genesis, specification, and uses.
- Lab 2: Study and identification of metallic minerals in hand specimens with reference to texture, structure, association, genesis, specification, and uses.
- Lab 3: Study and identification of industrial rocks and minerals in hand specimens with reference to texture, structure, association, genesis, specification, and uses.
- Lab 4: Study and identification of gemstones/energy minerals in hand specimens with reference to texture, structure, association, genesis, specification, and uses.
- Lab 5: Study of parts and working principles of ore microscope and techniques of preparation of polished section of ore minerals.
- Lab 6-7: 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 8: Study of geo-thermometry/geo-barometry and fluid inclusion-related techniques, parameters and calculations.
- Lab 9: Dating techniques of minerals.

Textbooks

1. Evans, A.M. (1993). *Ore Geology and Industrial Minerals, An Introduction* (third edition); Blackwell Scientific Publications, 379p.
2. Guilbert and Park (2007) (Reissued). *The Geology of Ore Deposits*. CBS Publisher and Distributors Pvt. Ltd. New Delhi, 985p
3. Smirnov, V. I. (1989). *Geology of Mineral Deposits*. Nem Chand and Brothers, 520p.
4. Sah and Paudyal (2023). *Geology of Mineral Deposits*. Publication: Stratigraphic Association of Nepal (SAN), 303p.
5. ESCAP (1993). *Atlas of Mineral Resources of Nepal*, vol. 9, UN publication.
6. Craig, J.R. and Vaughan, D.J. (1981). *Ore Microscopy and Ore Petrography*, John Wiley and Sons Inc., New York, 190p.

Reference Books

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.
5. Journals of Nepal Geological Society and Bulletin of Department of Geology, Tribhuvan University, Kirtipur, Kathmandu.

Part B: EXPLORATION GEOPHYSICS

(1 credit, 45 hours)

Course Contents:

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 practical 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.

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 Books

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.