नेपाल विद्युत प्राधिकरण

प्राबिधिक सेवा, विविध समूह, जियोलजी उपसमूह, तह-७, जियोलजिष्ट पदको
खुल्ला प्रतियोगितात्मक लिखित परीक्षाको पाठ्यक्रम

१. लिखित परीक्षाको विषय, पूर्णाङ्क, परीक्षा प्रणाली, प्रश्नसंख्या, अंकभार र समय निम्नानुसार हुनेछ ।

पत्र	विषय	पूर्णाङ्क	उत्तिर्णाङ्क	परीक्षा प्रणाली		प्रश्न संख्या	प्रति प्रश्न अंकभार	समय
प्रथम	सामान्यज्ञान तथा सेवा सम्बन्धि सामान्य विषय	१००	४०	क) सामान्यज्ञान र बौद्धिक परीक्षण	वस्तुगत वहु बैकल्पिक प्रश्न	२५	२	२ घण्टा
				(ख) सेवासम्बन्धी सामान्य बिषय	छोटो उत्तर आउने प्रश्न	१०	५	
द्वितीय	सेवा सम्वन्धी	१००	४०	विषयगत	लामो उत्तर आउने प्रश्न	१०	१०	३ घण्टा

२. बस्तुगत प्रश्नमा प्रत्येक प्रश्नका चार वटा सम्भाव्य उत्तर दिइने छ । जस मध्ये एउटा सही उत्तरमा (लोकसेवा आयोगले तोके बमोजिम) चिन्ह लगाउने वा लेख्नु पर्नेछ । गलत उत्तर बापत प्रति गलत उत्तर २० प्रतिशतका दरले अंक घटाइनेछ ।

३. प्राबिधिक सेवा अन्तर्गतका सबै समुह/उपसमुहहरुको प्रथम पत्रको पाठ्यक्रम एउटै हुनेछ । प्रथम पत्रको लिखित परीक्षा सबै समूह/उपसमूहका लागि संयूक्त रुपमा एउटै प्रश्नपत्रवाट एकैदिन वा छुट्टाछुट्टै प्रश्नपत्रवाट छुट्टाछुट्टै दिन हून सक्नेछ ।

४. प्रथमपत्र र द्वितीयपत्रको परीक्षा फरक फरक हुनेछ । द्वित्तिय पत्रमा २ खण्डहरु हुनेछन् । प्रत्येक खण्डको लागि फरक फरक उत्तर पुस्तिका प्रयोग गर्नुपर्नेछ ।

५. लिखित परीक्षाको माध्यम भाषा नेपाली वा अंग्रेजी वा दुवै हुन सक्नेछ ।

६. सामान्यत: प्रत्येक इकाईबाट प्रश्नहरु सोधिनेछन् । प्रत्येक इकाईको अंकभार तोकिए बमोजिम हुनेछ । लामो उत्तर दिनुपर्ने प्रश्न एकै वा खण्ड खण्ड गरी (दुइ वा सो भन्दा बढी) सोध्न सकिनेछ । यस्तो प्रश्न एक भन्दा बढी इकाइबाट पर्ने गरी सोध्न सकिनेछ ।

७. यस पाठ्यक्रममा जेसुकै लेखिएको भएता पनि पाठ्यक्रममा परेका ऐन, नियमहरु परीक्षाको मिति भन्दा ३ महिना अगाडि (संशोधन भएका वा संशोधन भई हटाइएका वा थप गरी संशोधन भई) कायम रहेकालाई यस पाठ्यक्रममा परेको सम्झनु पर्दछ ।

८. परीक्षामा कालो मसी भएको कलम वा डटपेन मात्र प्रयोग गर्नुपर्नेछ ।

प्रथमपत्र: सामान्य ज्ञान तथा सेवासम्बन्धी सामान्य बिषय
(प्राबिधिक सेवा, तह–७ का सबै समूहका लागि)

खण्ड (क): सामान्य ज्ञान र बौद्धिक परीक्षण **[५० अंक]**

१. सामान्यज्ञान : **(१५x२=३०)**

क) नेपालको भूगोल र आर्थिक तथा सामाजिक कृयाकलाप: धरातलीय स्वरुपको किसिम र विशेषता, नेपालमा पाईने हावापानीको किसिम र विशेषता, नदीनाला, तालतलैया, खनिज पदार्थ, प्राकृतिक स्रोत साधन, विद्युत, शिक्षा, स्वास्थ्य र सञ्चारसम्बन्धी जानकारी

ख) नेपालको सामाजिक एवं सांस्कृतिक अवस्था: प्रथा, परम्परा, धर्म, जातजाति, भाषाभाषी, कला, संस्कृति र साहित्य

ग) नेपालमा विद्युत विकास, ऊर्जाका श्रोत र सम्भावना

घ) नेपालको संघीय, प्रादेशिक र स्थानीय संरचना तथा शासन प्रणालीसम्बन्धि जानकारी

ङ) विश्वको भूगोल: महादेश, महासागर, अक्षांश, देशान्तर, अन्तर्राष्ट्रिय तिथि रेखा, समय, पर्वतश्रृंखला, नदी, हिमनदी, ताल, हिमताल

च) अन्तर्राष्ट्रिय सम्बन्ध तथा संघ/संस्था: संयुक्त राष्ट्र संघ र यसका एजेन्सीहरु (UNO and Its Agencies, दक्षिण एशियाली क्षेत्रीय सहयोग संगठन (SAARC) सम्वन्धी जानकारी

छ) राष्ट्रिय तथा अन्तराष्ट्रिय महत्वका समसामयिक घटना तथा नविनतम गतिविधिहरु

२. बौद्धिक परीक्षण:

२.१ Verbal and Non-verbal Aptitude: (१०x२=२०)

Vocabulary, Alphabetical ordering of words, Classification, Coding-Decoding, Insert the missing character, Direction and Distance sense test, Ranking order test, Relationship Test, Logical sequence of words, Common sense test, Assertion and Reason, Logical reasoning, Figure series, Figure analogy, Figure Classification, Figure Matrix, Pattern completion/finding, Construction of squares and triangles, Analytical reasoning.

२.२ Numerical Ability and Quantitative Aptitude :

Arithmetical reasoning, Insert the correct mathematical signs, Decimal and Fraction, Percentage, Ratio, Average, Profit and Loss, Time and work.

खण्ड (ख): सेवासम्बन्धी सामान्य बिषय (५० अङ्क)

1. Constitution, Act and Rules 3*5= 15

1.1. Present Constitution of Nepal
1.2. Nepal Electricity Act, 2041
1.3. Nepal Electricity Authority, Present Employee Service by laws
1.4. Electricity Regulatory Commission Act, 2074
1.5. Electricity Act, 2049 and Electricity Regulation, 2050
1.6. Public Procurement Act, 2063
1.7. Nepal Electricity Authority, Present Financial Administration by laws
1.8. Corruption Control Act, 2059
1.9. Good Governance (Management and Operation) Act, 2064
1.10. Land Acquisition Act, 2034
1.11. Environment Protection Act, 2053 and Environment Protection Regulation, 2054

2. Electricity Development in Nepal 2*5= 10

2.1. History of power development in Nepal; energy supply demand trends
2.2. Recent trends in power sector reform; Hydropower potential of Nepal and prospects and challenges for its development
2.3. Nepal Electricity Authority: objective, functions, corporate structure, achievement and challenges
2.4. Concept of NEA Restructuring in federal context
2.5. Silent features of energy crisis decade by government of Nepal

3. Development 1*5= 5

3.1. General concept of development administration
3.2. Planning in Nepal: efforts, achievement and challenges
3.3. Sustainable Development
3.4. Public Private Partnership

4. Management and financial analysis: 2*5= 10

4.1. Concept of Management
4.2. Motivation, Leadership, Control, Coordination and Team work, Decision making
4.3. Corporate planning and strategic management
4.4. Corporate social responsibility
4.5. Project management: Use of network models like CPM, PERT, manpower planning and resource scheduling; project monitoring and control; project control cycle

4.6. Financial analysis: Methods of financial analysis such as benefit cost ratio, internal rate of return, net present value, payback period, minimum attractive rate of return and their application; Concept of EIRR and FIRR; tariff structure

5. New Trends of Power Sector **2*5= 10**

5.1. Various Sources of Energy: trend, Possibilities and challenges
5.2. Role of IPP (Independent Power Producer), opportunities and challenges
5.3. Power Purchase Agreement (PPA), Power development agreement (PDA)
5.4. Concept of Energy Pool Market and Energy Banking
5.5. Regional and sub regional interconnections with Nepalese grid

द्वितिय पत्र: सेवा सम्वन्धी
(जियोलजी उपसमूहका लागि) १०० अङ्क

Section: A {5x10=50}

1. Geology of Nepal Himalaya

General Concept of Himalaya and its regional framework;

Tectonic Division of Himalaya and Stratigraphy: Terai, Sub-Himalaya, Lesser Himalaya, Higher Himalaya, and Tethys Himalaya.

Major geological structures: Main Frontal Thrust (MFT), Main Boundary Thrust (MBT), Main Central Thrust (MCT), and South Tibetan Detachment System (STDS).

Seismicity: Seismo-tectonics of Himalaya, seismicity of Nepal Himalaya, historic earthquakes, recent micro-seismicity, active faults and neo-tectonic activity, paleo-seismicity, seismic hazards in Nepal and seismic network of Nepal.

Evolution of the Himalaya: Geological evolution of Himalaya during Precambrian, Paleozoic, Mesozoic and Cenozoic eras, Magmatism and Metamorphism. Recent advances, existing problems and future tasks in the research of Nepal Himalaya.

2. Igneous and Metamorphic Petrology

2.1 Igneous Petrology

Concept of thermodynamics applied to rocks: Basic terminologies, state variables, first law of thermodynamics, stability and equilibrium, reversible and irreversible processes, entropy and second law of thermodynamics, third law of thermodynamics, Gibb's Free Energy for closed and open systems, chemical potential, Clausius-Clapeyron equation, Phase rule.

Kinetic aspects and phase-equilibria: Formation of crystals in a liquid, vesiculation, causes of boiling, controls on explosive volcanic eruptions, cooling of magmatic bodies, crystallization in binary eutectic system, binary solid solution, ternary eutectic system, ternary solid solution.

Diversification and ascent of magma: *D*iversification, ascent and emplacement of magmas.

***Petrography, classification, field relations and genesis of igneous rocks*:** Calc-alkaline volcanic and plutonic rocks, sub alkaline basaltic and ultramafic rocks, alkaline rocks.

2.2 Metamorphic Petrology

Concept of metamorphism: Definition and factors of metamorphism, temperature and pressure of metamorphism, bulk-rock composition, prograde and retrograde metamorphism, types of metamorphism, P-T-t path, metamorphic zones and isograds. Metamorphic reactions.

Composition-paragenesis diagrams: ACF, AKF and AFM diagrams, petrogenetic grid.

Metamorphic fabrics: Isotropic and anisotropic fabrics, influence of composition on imposed fabric, solid-state crystal growth, stress and deformation, ductile flow, diffusive flow and pressure solution, role of fluids in deformation, origin of anisotropic fabric in metamorphic tectonites.

Relationships between metamorphism and tectonic processes: Classification of three types of metamorphism based on P/T ratio, paired metamorphic belts, metamorphic belts in arc zones, metamorphic complexes in subduction zones, metamorphism in continental collision zones, and metamorphism in continental extension regions.

Metamorphism: Metamorphism ***of***pelitic, psammitic, calcareous, granitic and basic igneous rocks.

3. Sedimentology,Stratigraphy and Paleontology

3.1 Sedimentology

Sedimentary particles: Transported in the solid state, precipitated and biogenic particles.

Sedimentary processes: Physical processes and dynamics of moving particles, Bio-chemical processes. Weathering and geochemical cycle of sediments.

Properties of sediments: Texture, grain size and provenance. Grain size and depositional processes. Shape and Roundness. Surface features. Manner of Packing and orientation. Maturity of sediments. Density, Porosity, Permeability.

Environment of deposition: desert, fluvial, lacustrine, glacial, coastal, deltaic, estuarine and marine environments.

Diagenesis: Dissolution, precipitations, cementation and compaction.

Classification of sediments and sedimentary rocks: Conglomerate, breccia, and gravel. Sand, sandstone, siltstone, argillite, shale and claystone. Limestone and dolomite. Volcanoclastic sediments. Cherts and other siliceous sediments. Iron bearing sediments, glauconite, phosphorite, and other evaporates. Carbonaceous sediments, coal and oil shale.

Structure of sedimentary rocks: Bedding and cross lamination, graded bedding. Sole marks, mud cracks, surface marks, penecontemporaneous deformation structures. Sandstone dykes and sills. Convolute beddings. Stromatolites and other biogenic structures.

Sedimentological study: Mechanical analysis of sediments. Grade scale. Grain size distribution. Phi scale. Normal distribution, Cumulative frequency distribution and its characteristics. Shape analysis and its significance. Mineral separation, mineral stability.Paleo-currents and paleogeography.

3.2 Stratigraphy and Paleontology

Background: Principles of stratigraphy, geological timescale, law of superposition.

Establishment of stratigraphic units: establishing of rock successions and working out of stratigraphic units. International guidelines or codes on stratigraphic classification and nomenclatures.

Correlation: Correlation of litho, bio, magneto and chrono-stratigraphic units. Limitation andsubjective nature of correlation. Construction of ancient sedimentary environments.Reduction of homonyms and synonyms by conducting correlations of rock successions/rock units.

New trends in stratigraphic studies: Magneto-stratigraphy, Rhythmo-stratigraphy, Echo-stratigraphy, and Tectono-stratigraphy.

Paleontology*:* paleobiogeography, paleoecology and paleoclimate.

Micropaleontology: Importance and application of microfossils; extraction methods in micropaleontology; microfossils, stable isotopes and ocean atmosphere history; microfossils as thermal metamorphic indicators. Microfossils from Nepal Himalaya.

Vertebrate Paleontology: Vertebrate origin, landmarks in vertebrate evolution. Overview of vertebrate classification, Evolution of Equidae and Probosidae. Human evolution, Hominoids from the Indian subcontinent, Neogene vertebrates from Nepal Himalaya.

Plant fossils: Evolution of plants through geological time; Gondwana flora; Neogene vegetation records from Nepal Himalaya.

Trace fossils**:** Morphology, classification and applications. Tracefossils from Nepal Himalaya.

Mass extinction: Process and Events. Extinction in the Ice ages.

4. Structural Geology and Tectonics

4.1 Structural Geology

Primary structures: Primary sedimentary structures and their significance.

Secondary structures: Morphology, geometry, classification and mechanism of fold, faults and shear zones, joints, foliation and lineation.

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

Superimposed folding*:* Concept, environment and mechanism

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.

Strain: Definitions. Displacement vector. Displacement field. Displacement gradient. Homogeneous and inhomogeneous deformations. Strain indicators. Strain ellipse and reciprocal strain ellipse. Lagrangian and Eulerian specifications. Homogeneous deformation of straight line. Circle and ellipse. Changes in lengths and orientation of lines in different zones with strain ellipse and corresponding geological structures.

Deformation mechanism: Cataclastic flow, pressure solution, intracrystalline formation, recovery, recrystallization (grain boundary migration recrystallization, subgrain rotation recrystallization, competing processes during deformation), solid state diffusion creep, grain boundary sliding and super plasticity, grain boundary area reduction, static recrystallization.

4.2 Tectonics

Continental drift: Continental reconstructions, Geologic evidence for continental drift, Paleoclimatology, paleontologic evidence for continental drift, paleomagnetism, sea floor spreading and transform faults.

The framework of plate tectonics: Plates and plate margins, distribution of earthquakes, distribution of earthquakes, distribution of earthquakes, distribution of earthquakes, relative plate motions, absolute plate motions, true polar wander, cretaceous superplume, direct measurement of relative plate motions, finite plate motions, stability of triple junctions, present day triple junctions.

Continental rifts and rifted margins: General characteristics of narrow rifts, General characteristics of wide rifts, volcanic activity, Rift initiation, Strain localization and delocalization processes, Rifted continental margins, Case studies: the transition from rift to rifted margin, The Wilson cycle.

Continental transforms and strike-slip faults: Fault styles and physiography, the deep structure of continental transforms, Transform continental margins, Continuous versus discontinuous deformation, Strain localization and delocalization mechanisms, measuring the strength of transforms.

Orogenic belts: Ocean–continent convergence, compressional sedimentary basins, continent–continent collision, arc–continent collision, terrene accretion and continental growth.

The mechanism of plate tectonics: Contracting Earth hypothesis, expanding earth hypothesis, implications of heat flow, convection in the mantle, the forces acting on plates, driving mechanism of plate tectonics, evidence for convection in the mantle, the nature of convection in the mantle, plumes, the mechanism of the supercontinent cycle.

Implications of plate tectonics: Environmental change, economic geology, natural hazards.

5. Mineralogy and Mineral Resources

5.1 Mineralogy

Crystallography: Unit cells and 2-D space lattices. Symmetry of lattices: Symmetry contents of planar point groups, plane lattices, plane groups. Three-dimensional lattices: Bravais lattices, screw axes, and glide planes.

Optical Mineralogy: Polarization of light. Uniaxial and biaxial crystals and indicatrices. Uniaxial and biaxial crystals,: Extinction, Interference color, Birefringence, and Sign of elongation. Uniaxial crystals under convergent light: Uniaxial interference figures; determination of optic sign of uniaxial crystals. 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.

Systematic Mineralogy: Mineral classification. Structures, diagnostic properties, and genesis of some mineral groups: SiO2, Feldspar, Clay minerals, Micas, Olivine, Garnet, Pyroxene, Amphibole, Calcite, Dolomite, Anhydrite, Gypsum, and Apatite.

6. Mineral Resources

***Mineral Resources*:** Ore minerals, their textures and structures development in open space and in crystalline aggregates. Endogenous and exogenous processes of formation and transformation of ore.

Stages of Mineral Resource Development: **Prospecting**: Geological controls for mineral deposits, prospecting criteria, guides, methods of prospecting, metallogeny, evaluation of territory on mineral resources, prognostic maps.

Exploration: Basic principles and methods of exploration, stages of exploration work, sampling, estimation of reserves and evaluation of deposits.

Mining: Methods, factors affecting the selection of mining methods. Surface mining and underground mining. Modes of entry to mineral deposits. Fundamental unit operations and cycles; Drilling or rock penetration methods; Blasting and rock fragmentation, Loading and excavation, Haulage and Hoisting, Auxiliary operations.

Processing: Processing, refining and fabricating of useful products, cutting and polishing; metallurgical treatments, agglomeration, mechanical concentration, blending, hand-sorting, crushing and grinding.

Marketing: Market survey, Demand analysis.

Mineral Resources of Nepal: Geological control, current status and future prospects of mineral resources of Nepal, Metallic, non-metallic, gemstones, and fossil fuels resources of Nepal.

Section: B {5x10=50}

7. Hydrogeology and Geomorphology

7.1 Hydrogeology

Introduction: Hydrologic cycle, global water resources and the hydrological balance.

Precipitation: Formation and forms of precipitation, types and measurements of precipitation data. Precipitation gages. Interpretation of precipitation data: Depth area duration analysis.

Variation in precipitation*:* Geographic variation, time variation, record rainfalls, Snow pack and snowfall measurement and variation.

Stream flow*:* Water stage; Manual gages. Stream flow hydrographs: characteristics of hydrograph, components of runoff, determination of total runoff.

Discharge and Transpiration: Estimating discharge and potential evapotranspiration from meteorological data. Estimating actual evapotranspiration from potential irrigation water requirements. Controlling evapotranspiration.

Soil moisture and Groundwater: Vertical distribution of groundwater, water table, infiltration, soil moisture,

Groundwater occurrence*:* aquifers, types of aquifers, unconsolidated aquifers, Study of springs: types and classifications of springs, recharge of springs, spring water geochemistry, delineation of spring protection zones, groundwater in permafrost regions.

7.2 Geomorphology

Introduction*:* Concepts, the geomorphological system, geomorphic scale.

Igneous activity and landforms*:* Intrusive and extrusive constructional forms, igneous destruction landforms.

Structure and landforms*:* Horizontal and domed structures, homoclinal structures, folded structures, faulted structures.

Lithology and landforms*:* Arenaceous, argillaceous, and calcareous landforms, rock strength, geomorphic processes and landforms.

Weathering*:* The earth-atmosphere interface, processes of weathering, rates of weathering, the weathered mantle.

Hill slopes*:* Introduction, characteristic slopes, classification of hill slopes, origin of hill slopes, hill slope erosion, and evolution of hill slopes.

Rivers*:* Significance, open-channel hydraulics, sediments transport, hydrology, river morphology, channel stability, example of river metamorphosis, rivers and valley morphology.

Drainage basins*:* The basin geomorphic unit morphometric analysis, morphometric control, drainage basin evolution, drainage basin response. *Fluvial depositional landforms*: Alluvial fans, valley fill, deltas.

Coastal geomorphology*:* Sea level, waves, and currents, beach processes and profile, shoreline processes and depositional forms, erosional coasts, sea-level variations, Organic coasts, coastal management.

Aeolian processes and landforms*:* Aeolian environments, aeolian sand movement, wind abrasion, Aeolian bed forms, coastal sand dunes, loess, snow drifting.

Glacier sedimentary system*:* Glaciers, glacier ice, glacier flow, rock debris in glaciers, processes affecting debris at the glacier sole, erosion by glaciers, deposition by glaciers, landforms of glacial deposition, the glacier melt water subsystem.

Morphogenetic landforms*:* Morphogenetic regions, humid tropical landforms, Tropical wet-dry landforms, arid and semi-arid landforms, cold, region landforms.

Climatic change and polygenetic landforms*:* Climatic change and its geomorphic effect.

8. Engineering Geology and Geohazards

8.1 Engineering Geology

The basis of Engineering Geology: Development and aims of engineering geology.

Geological Materials: Important characteristics of geological materials, their properties, density and unit weight, porosity and permeability, strength, deformation, abrasiveness, environmental reactivity, index tests

Maps: Maps, geological map making, understanding geological maps, mapping at a small scale, mapping at a large scale, engineering geological maps, quality of published information and limitation of liability, aid to engineering geological mapping

Field tests and measurements: Tests in boreholes: resistance to penetration, strength and deformation test, permeability test, in situ stress measurement, tests in large diameter boreholes, shafts and tunnels, insitu shear test, other tests.

Tunnel and dam site investigation: Tunnel: Geological condition of tunneling, methods of site selection (feasibility, detailed and preconstruction stage). Dam site: Definition, terminology and types of dam, geology and dam site, problems and failures in dam, geological investigation of dam site, slope protection of dam site, foundation work for dam, grouting equipment and methods, site selection criteria for dam (preliminary investigation, detailed exploration, preconstruction stage, construction stage).

Road, pavement and railroad investigation: Terminology and classification. Road and pavement foundation, rigid and flexible foundation, geotechnical investigation for pavements, geological investigation of mountain road, geological investigation of valley road, geological investigation of road in plane area, road alignment survey, Rail road foundation, geological investigation of rail road in mountain area, geological investigation of rail road in plane area.

Bridge, embankment and canal investigation: Classification of bridge and parts of bridge, types of abutment, types of piers, bridge foundations, investigation of bridge foundation. *Embankment***:** terminology and classification, cut and excavations, embankment foundations, embankment control, investigation for embankment. *Canal*: terminology and classification, canal linings and canal drains, canal investigations.

Foundation of Building*:* Types of building foundation, residential, commercial and industrial buildings, power plants and pumping stations, Selection of foundation types, foundation problems and exploratory programs, foundation on unstable ground, groundwater problems in foundations, building foundation on fills.

8.2 Geohazards

Landslides: Terminology, classification, causes, stability of slopes, factor of stability, causes and effects of slope movements, threshold slopes, basic mechanism of failure, kinematic and numerical slope stability analysis, investigation and mitigation of landslides, landslide hazard mapping techniques, landslide risk assessment, landslide control and management, Bioengineering techniques for slope stabilization and watershed management.

Floods: Open channel hydraulics, fluvial landforms, fans, valley, deltas, river types versus channel stability, sediment grain flow, sediment fluid interaction, fluid dynamics and sediment transport, threshold of erosion, transportation and deposition. Debris flows: classification, mechanism of flow, causes and effects, occurrence of debris flow. Flooding: flood hydrograph, factors contributing flooding, flood frequency analysis, flood hazard mapping techniques and design of flood and debris flow control measures.

Glacial lake outburst flood (GLOF): Glacier flow including catastrophic flows, sediment erosion, transport and deposition, rock debris in glaciers, erosion and deposition glacier landforms, distribution of glaciers in Nepal, Factors contributing GLOF, mitigation techniques, potentially dangerous glacial lakes in Nepal.

Subsidence and settlement: Causes of settlements and subsidence, investigation of settlement and subsidence, hazard and risk analysis and mapping of subsidence.

Earthquake: Mechanism, causes .and seismic waves, Types of Earthquake, Elastic rebound Theory, Intensity, magnitude, and effects of Earthquake. Earthquake recording and ground motion parameters.

9. Geophysics and Geochemistry

9.1 Geophysics

Concepts: Scopes and application of geophysical methods in subsurface investigations. Merits and limitations of geophysical methods..Major fields of geophysical exploration, significance and measurement of physical quantities involved, factors giving rise to noise, qualitative and quantitative interpretations, ambiguities in interpretation, integrated geophysical methods.

Gravity methods*:* Normal gravitational field, determination of absolute gravity, gravimeters, gravity anomalies, techniques of gravity surveys, data reduction, gravity anomalies, qualitative and quantitative interpretation, application of gravity methods, regional geological and tectonic studies, exploration for minerals, oil and gas, engineering problems.

Magnetic methods*:* Basic concepts and definitions, magnetometers and types of magnetometers, magnetic surveys, data reduction, qualitative and quantitative interpretations, application of magnetic methods.

Electrical methods*:* Electrical properties of rock and minerals, electrical field caused by a point charge, SP method, resistivity methods, Mise-a-la-masse method, equipotential line method, IP method, magneto telluric and EM methods. *Basic EM theory:* Amplitude and phase methods, VLF method, Turam and Slingram method, basic principles of magneto telluric methods. Resistivity methods: physical and geological basis of resistivity method, Resistivity survey and resistivity sounding; Vertical electrical sounding (VES), Basic concepts of electrical resistivity tomography.

Ground penetrating radar (GPR): Basic theory, radar reflection profiling, field arrangement and interpretation.

Seismic methods*:* Principles of exploration seismograph, sources of seismic energy. Seismic survey in land, *Seismic refraction method*: time-distance relationships, data acquisition in seismic refraction, interpretation by Plus-Minus method, generalized reciprocal method, application and case histories. *Seismic reflection method*: time distance relationship, data acquisition in seismic reflection. Processing and interpretation of seismic reflection data Common midpoint method. Basic concept of seismic refraction tomography.

Radioactivity method*:* Theoretical background, radioactivity of rocks.

Geophysical well logging: Well drilling, formation evaluation, electrical logging, radioactivity logging, elastic wave logging, thermal wave logging, sonic logging.

9.2 Geochemistry

Introduction*:* Principles of Geochemistry, structure and composition of the earth, elements, structures of the atoms, molecules and ions, Lithosphere, hydrosphere, atmosphere, biosphere.

Distribution of the elements*:* Goldschmidt's geochemical classification, distribution of elements in igneous rocks metamorphic and sedimentary rocks.

Geochemical cycles*:* Earth as a physicochemical system; the crust as a separate system, geochemical cycle, Energy changes in the geochemical cycle.

Geochemistry of Stable isotopes*:* Fractionation of stable isotopes, modes of isotopes fractionation, paleothermometer, isotope cycle of water, paleoclimatology, Oxygen, Sulphur, Carbon, and Hydrogen isotopes.

Geochemistry of Radioactive Isotopes: Radioactive decay, Uranium-Thorium-Lead system, Rubidium-Strontium system, Samarian-Neodymium system, Potassium-Argon system, Carbon, Lu-Hf system, Re-Os system, cosmogenicradionucleides.

10. Rock Mechanics and Soil Mechanics

10.1 Rock Mechanics

Rock strength: Scale effects and rock strength, classes of rock strength; shear strength of discontinuities, definition of cohesion and friction angle, friction angle of rock surfaces, shearing on an inclined plane, surface roughness, discontinuity infilling; influence of water on shear strength of discontinuities; shear strength of rock masses by back analysis of slope failures; Hoek-Brown strength criterion for fractured rock masses: Generalized Hoek-Brown strength criterion, Modulus of deformation, Mohr-Coulomb criterion.

Rock mass classification: Collection of field data, estimation of rock mass rating and its applications, *Rock mass quality Q:* The Q system, joint orientation and the Q-system, updating the Q-system, collection of field data, classification of the rock mass, estimation of support pressure, unsupported span, rock mass characterization. *Rock mass number*: interrelation between Q and RMR, prediction of ground conditions and support pressure.

Groundwater flowing rock mass*:* Field identification of groundwater conditions, interpretation of groundwater conditions; developing a groundwater model from the field data, groundwater effects on slope stability, reduction in shear strength, reduction in frictional strength, effect of seepage direction.

Rock slope stability: Effects of discontinuities on slope stability, Orientation of discontinuities, Stereographic analysis of joint data, Pole, point, contour data, Great circles, Lines of intersection. Identification of modes of slope instability Kinematic analysis, Plane failure, Wedge failure, Toppling failure, Friction cone, Applications of kinematic analysis.

Stabilization of rock slopes: Rock slope stabilization programs, Stabilization by rock reinforcement, Stabilization by rock removal, Resloping and unloading, Trimming, Scaling, Rock removal operations, Protection measures against rock falls.

9.2 Soil Mechanics

Soil and its properties: Definition of soil, terminology of different soil types, particle size and gradation, clay structures, volumetric relationships, water content, volume-mass relationships, volume-weight relationships, specific gravity, mass density in terms of water content, determination of water content, specific gravity, void ratio, porosity, degree of saturation, and permeability. *Particle size analysis*: sieve and hydrometer analyses, plasticity, liquidity and consistency tests and indices, flow index, toughness index, sensitivity, and thixotropy.

Soil classification: AASHTO Classification System, Unified Soil Classification System, Comparison of AASHTO and USC Systems, field identification of soils.

Stresses and strains: Basic definition and sign conventions for stresses, Equations of static equilibrium, Concept of strain, Hooke's law, plane strain problems; equations of compatibility for

three-dimensional problems, stresses on an inclined plane and principal stresses for plane strain problems, strains on an inclined plane and principal strain for plane strain problems, stress components on an inclined plane, principal stress, and octahedral stresses three-dimensional case, strain components on inclined plane, principal strain three-dimensional case.

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

Shear strength of soils: Stress system with principal planes parallel to the coordinate axes, Mohr's Circle, important characteristics of Mohr's Circle, Mohr-Coulomb theory, Direct shear test, Triaxial Tests on cohesive soils, and cohesionless soils, Relationship between undrained shear strength and effective overburden pressure, unconfined compression test, Vane shear test, Pore pressure parameters, Mohr-Coulomb failure criterion, stress path, sand liquefaction, and shear characteristics of cohesive soils.

Bearing capacity of shallow foundation: Basic definitions, gross and net footing pressure, Rankine's analysis, Hogetogler and Terzaghi's analysis, Prandtl's analysis, Terzaghi's bearing capacity theory, Types of shear failures, effect of water table on bearing capacity, bearing capacity of square and circular footings, foundation on layered clay, bearing capacity from standard penetration test, settlement of foundation, loads for settlement analysis, immediate settlement of cohesive soils and cohesionless soils, consolidation settlement in clays, settlement of foundations on cohesionless soils, allowable soil pressure for cohesionless soils and cohesive soils, Housel's method for design of foundation.

11. Tunneling and Underground Excavation

Concept: Use and scope of underground excavation, methods of excavation, tunnel boring machine(TBM), drilling and blasting, trenchless technology.

Underground supports*:* shield supports, remote and automation support, lining, reinforcements, rock bolting, cable bolting, rock anchoring, roof stretching.

Underground environment*:* dust suppression, ventilation, lighting, communication, fire protection, underground openings: dimensions, shape, structural response, sequence of excavation, rock conditions, stress distribution and failure prediction, caving and subsidence, failures in underground excavation. Structurally control instability, influence of geometry, in-situ stress, pillar design and failure, fracture propagation, stiffness, energy and stability, static and dynamic response of rock material during excavations

Design and construction of large excavation*:* hydro-power station caverns, metro railways, large diameter trenches, water carrying tunnels, excavation for waste disposal, stability evaluation and analysis – monitoring, back analysis, case histories, instrumentation and monitoring of load and deformational characteristics of rock mass, conventional and non-conventional monitoring of roof, side walls, excavation in difficult situations – squeezing, freezing and swelling rock mass.

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