Fourth Year- (U.G. with Honours)

Entry requirement	(After completing requirements of a 3-year bachelor's degree (120 credits) and 2 additional credits under SSD, will be allowed to continue studies in the fourth year of the undergraduate programme leading to a four-year bachelor's degree (Honours).							
Course Type	**Semester-VII**				**Semester-VIII**			
	Subject/Title	No. of Paper	Credits		Subject/Title	No. of Paper	Credits	
			T	P			T	P
Major Subject (one)	Geohydrology (MJ-01)	1	5	-	Igneous & Metamorphic Petrology (MJ-05)	1	5	-
	Structure and Tectonics (MJ-02)	1	5	-	Mineral Exploration & Mining Geology (MJ-06)	1	5	-
	Engineering Geology (MJ-03)	1	5	-	Sedimentology (MJ-07)	1	5	-
	Practical-Major (MJ-04) (MJ-01+02+03)	1	-	5	Practical-Major (MJ-08)	1	-	5
	Remote Sensing and GIS **Elective-1** (MJE-01)	1	4	-	Natural Hazards **Elective-2** (MJE-02)	1	4	
Minor Subject (one)	Minor-1 Environmental Geology (MI-1A)/ Marine Geology (MI-1B)	1	2	2	Minor-2 Paleoclimatology (MI-2A)/ Himalayan geology (MI-2B)	1	2	2
Total		6	21	7		6	21	7
NHEQF Level- 6	***Student on exit after successfully completing four years (i.e., securing minimum required 176 credits along with securing an additional 2 credits under SSD coursework) will be awarded "Four years bachelor's degree (Honours)", in a related field/discipline***							
Note: In case of Core Major Elective course, if the department wants to introduce a practical component, the department may bifurcate the total 4 credits between theory and practical. ***Note: If the minor course is offered without a practical component, the department must allocate 4 credits to the theory component. Electives may be offered by the departments under the Minor course.***								

Note: In the case of electives (Major or Minor), departments must offer a minimum of two electives; out of which students will select one.

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H.N.B. Garhwal University
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Fourth Year- (U.G. Honours with Research)

Entry requirement	(After completing requirements of a 3-year bachelor's degree (120 credits) and 2 additional credits under SSD, candidates who meet a minimum CGPA of 7.5 will be allowed to continue studies in the fourth year of the undergraduate programme leading to a four-year bachelor's degree (Honours with Research).							
Course Type	**Semester-VII**				**Semester-VIII**			
	Subject/Title	No. of Paper	Credits		Subject/Title	No. of Paper	Credits	
			T	P			T	P
CORE-Subject	Geohydrology (MJ-01)	1	5	-	Igneous & Metamorphic Petrology (MJ-05)	1	5	-
	Structure and Tectonics (MJ-02)	1	5	-				
	Practical-Major (MJ-03) (MJ-01+02)	1	-	5	Practical-Major (MJ-06)	1	-	3
	Remote Sensing and GIS **Elective-1** (MJE-01)	1	4	-	Natural Hazards **Elective-2** (MJE-02)	1	4	-
	Research Methods in Geology (MJ-04)	1	5	-	Dissertation (MJ-07)	1	-	12
Minor Subject (One)	Minor-1* Environmental Geology (MI-1A)/ Marine Geology (MI-1b)	1	2	2	Minor-2 Paleoclimatology (MI-2A) /Himalayan Geology (MI-2B)	1	2	2
Total		6	21	7		5	11	17
NHEQF Level- 6	***Student on exit after successfully completing four years (i.e., securing minimum required 176 credits along with securing an additional 2 credits under SSD coursework) will be awarded "Four years bachelor's degree (Honours with Research)", in a related field/discipline***							

Note: In case of Core Major Elective course, if the department wants to introduce a practical component, the department may bifurcate the total 4 credits between theory and practical.
Note: If the minor course is offered without a practical component, the department must allocate 4 credits to the theory component. Electives may be offered by the departments under the Minor course

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H.N.B. Garhwal University
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B.Sc. UG with Honours; Semester VII
Major Subject (MJ-01-UGH)/Geohydrology
Total Credits-05; Total marks 100 (70 End Term Theory+30 Sessional Theory)

Unit-I: Origin, occurrence, and distribution of groundwater, hydrological cycle, hydrological properties of rocks, water table fluctuations, springs, groundwater provinces of India.
Unit-II: Theory of groundwater flow, Darcy's law - its application and limitation, permeability determination, types of well - unconfined, confined
Unit-III: Groundwater quality - physical and chemical properties, problems of arsenic and fluorides, groundwater contaminations.
Unit-IV: Geophysical methods of groundwater exploration - electrical (resistivity), seismic, gravity methods, groundwater problems and management, artificial recharge, groundwater legislation,

Books recommended:

1. Bouver, H. (1978): Groundwater Hydrology, McGraw Hill.
2. Fetter, C.W. (1990): Applied Hydrogeology, CBS Pub. New Delhi.
3. Todd, D.K. (19880: Ground Water Hydrology, John Wiley & Sons, New York.
4. Davies, S.N. and Dc-West, R.J.N. (1966): Hydrology, John Wiley & Sons, New York.
5. Raghunath, H.M. (1983): Ground Water, Wiley Eastern Ltd. Calcutta.

B.Sc. UG with Honours; Semester VII
Major Subject (MJ-02-UGH)/Structure and Tectonics
Total Credits-05; Total marks 100 (70 End Term Theory+30 Sessional Theory)

Unit-I: Stress and strain relationship of elastic, plastic and viscous materials, factors affecting the behaviour of rocks, kinematic analysis, Mohr's Circles, strain and stress ellipsoids. Measurement of strain in deformed rocks.
Unit-II: Classifications and mechanics of folds, faults, joints, unconformities, boudins, cleavage, lineation, foliation.
Unit-III: Concept of Plate Tectonics, tectonic history of India and origin of Himalaya. Major tectonic features of the oceanic and continental crusts. Seismotectonics/geodynamics of Indian plate.
Unit-IV: Mid oceanic ridges, Deep Sea tranches, Paleo-magnetism, Sea floor spreading, Island arcs, Oceanic islands and Volcanic arcs.

Books Recommended:

1. Davies, A.Z.: Structural Geology.
2. Ghosh, S. K.: Structural Geology, Fundamental and Modern Concepts, Pergamon Press.
3. Ramsay J. G. (1967): Folding and fracturing of Rocks, McGraw Hill Pub.
4. Ramsay J.G. & Huber M. I. (1983, 1987): The Techniques of Modern Structural Geology-I & II, Strain Analysis, Academic Press.
5. Hobbs, B.E., Means, W.D. & Williams, P.F. (1976): An outline of Structural Geology, John Wiley and Sons publ.
6. Turner, F.J. & Weiss, L.E. (1963): Structural analysis of Metamorphic Tectonites, McGraw Hill publ.
7. Condie Kent, C. (1989): Plate Tectonics and Crustal Evolution.
8. W. J. Kious & Robert I.T.: This dynamic of Earth: the story of Plate Tectonics USGS publ.

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Srinagar (Uttarakhand) 246174

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9. Moores, E. & Twiss, R.J., 1995: Tectonics. Freeman publ.
10. Keary, P. & Vine, F.J. 1990: Global Tectonics. Blackwell scientific publ.
11. Valdiya, K.S. 1998: Dynamics Himalaya. Univ. Press.

B.Sc. UG with Honours; Semester VII
Major Subject (MJ-03-UGH)/Engineering Geology
Total Credits-05; Total marks 100 (70 End Term Theory+30 Sessional Theory)

Unit I: Engineering properties of rocks, Building stones and their distribution in India.
Unit II: Dam, Types and their Geological and Environmental considerations, Reservoirs, their Geological problems.
Unit III: Tunnels - Geological and Structural considerations of tunnelling, Landslides - Classification, Causes and Preventive measures.
Unit IV: Bridges - Type and Foundation problems, Soils and Soil groups of India,

Books Recommended:

1. Bangar, K.M. (2012): Principles of Engineering Geology. Standard Publishers
2. Bell, F.G. (2007): Engineering Geology. Butterworth-Heinemann, Elsevier.
3. Reddy, D.V. (2010): Engineering Geology. Vikas Publishing House, India.
4. Kesavulu, N. Chenna (2009): Engineering Geology. Macmillan India Ltd.
5. Verma, B.P. (2002): Rock Mechanics for Engineers. Khanna Publ., New Delhi.
6. Singh, Parvin (2008): Engineering and General Geology. S.K. Kataria & Sons.
7. Gokhale, K.V.G.K. (2004): Geology & Engineering. CBS Publishers & Distri.
8. Punmia, B.C. (2005): Soil Mechanics and Foundations. Laxmi Publ., New Delhi.
9. Ranjan, G. & Rao, ASR (2007): Basic & Applied Soil Mechanics. New Age Pub.
10. Bindra, S.P. (2007): Bridge Engineering. Dhanpat Rai Publications.

B.Sc. UG with Honours; Semester VII
Major Practical (MJ-04-UGH)/(MJ01+MJ02+MJ03)
Total Credits-05; Total marks 100 (70 End Term Practical +30 Sessional Practical)

Geohydrology (20+10)

- Delineation of hydrological boundaries on water table, permeability estimation.
- Analysis of hydrographs and estimation of infiltration capacity.
- Estimation and interpretation of TDS
- Exercise on ground water exploration using remote sensing techniques.

Structure and Tectonics (30+10)

- Preparation and interpretation of geological maps and sections
- Exercises on strain measurements
- Study of various tectonic models
- Stereographic presentation of structural data

Engineering Geology (20+10)

- Study of Soil Profiles, Building stones;
- Engineering properties and Identification
- Plain Table Survey (Radiation and Intersection methods)

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Department of Geology
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(A Central University)
Srinagar (Garhwal)-246174
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B.Sc. UG with Honours; Semester VII
Major Elective (MJE-01-UGH)/Remote Sensing and GIS
Total Credits-04; Total marks 100 (70 End Term Theory+30 Sessional Theory)

Unit I: Fundamental concepts of Remote Sensing; applications in geosciences
Unit II: Aerial photography, photogrammetry concepts, and remote sensing Satellites
Unit III: Visual interpretation of aerial photo/satellite images: Photo-recognition elements.
Unit IV: Fundamentals of Geographical Information System (GIS).

Books Recommended:

1. F.F. Sabine; Remote Sensing- Principals and Interpretation
2. Lillesand R. M. and Kiefer R.W.: Remote Sensing and Image Interpretation
3. R. P. Gupta: Remote Sensing
4. Demers, M. N.: Fundamentals of Geographic Information Systems
5. Bonham Carter G. F.: Fundamentals of Geographic Information Systems for Geoscientists

B. Sc. UG with Honours; Semester VII
Minor Subject (MI-01A-UGH)/Environmental Geology
Total Credits-04

Theory: 02 Credits (70 End Term Theory + 30 Sessional Theory)
Unit-I: Introduction to environmental geology, its fundamental concepts, and scope
Unit-II: Environmental ethics; Ecosystem Concepts (atmosphere, hydrosphere, lithosphere and biosphere)
Unit-III: Soil erosion; land resources, natural hazards; depletion of water resources: causes and impact;
Unit-IV: Renewable and non- renewable sources of energy; hydrological cycle, carbon cycle, concept of climate change.

Books Recommended:

1. K. S. Valdiya:- Environmental Geology, Indian Context.
2. E. A. Keller: - Environmental Geology.
3. P. T. Flawn:- Environmental Geology.
4. D. Howard and I. Remson: - Geology in Environmental Planning.

Practical: 02 Credits (70 End Term Practical + 30 Sessional Practical)

Evaluation of environmental impact of air pollution and groundwater pollution; identification of natural disaster sites based on topographic and geological maps; identification of renewable and non- renewable sources of energy in the context of India.

B.Sc. UG with Honours; Semester VII
Minor Subject (MI-01B-UGH)/Marine Geology
Total Credits-04

Theory: 02 Credits (70 End Term Theory+30 Sessional Theory)
Unit-I: Ocean Basins and Tectonics - Origin and classification of ocean basins, Sea-floor spreading, mid-ocean ridges, and plate tectonics.

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Unit-II: Marine Sedimentation and Coastal Processes - Types of marine sediments: terrigenous, biogenic, and hydrogenous, Brief introduction of Sediment transport and deposition in coastal and deep-sea environments, Ocean circulation and impact of climate change.

Unit III: Coastal geomorphology and Palaeoceanography - Sea level changes; Coastal geomorphology: beaches, dunes, and estuaries, Palaeoceanographic archives: sediments, corals, and foraminifera.

Unit IV: Marine Resources - Economic resources: polymetallic nodules, gas hydrates, and hydrocarbons., Environmental impacts of marine mining, Coastal zone management and marine pollution.

Books Recommended:

1. Marine Geology by James P. Kennett; A comprehensive introduction to marine sediments, plate tectonics, and seafloor processes.
2. Marine Geology by Jon Erickson; Covers diverse marine geological topics, including oceanic ridges, trenches, and deep-sea exploration.
3. Seafloor Geomorphology as Benthic Habitat by Peter Harris and Elaine Baker Focuses on seafloor mapping and its applications in marine conservation and geology.
4. Geological Oceanography by Fran k J. P. Veizer; Explores marine geological processes with an emphasis on ocean chemistry and sedimentology.
5. Marine Geology: Exploring the New Frontiers of the Ocean by Roger N. Anderson; Discusses advanced research and cutting-edge exploration technologies.
6. The Oceans and Marine Geology; by Trujillo and Thurman; An introductory textbook combining oceanography with geological processes.
7. Climate and Marine Cycles by John G. Anderson; Connects marine geological processes with climate evolution over geological timescales.
8. Ocean Circulation and Sedimentation by Cesare Emiliani; Examines the interplay between ocean currents and sedimentation patterns.

Practical: 2 Credits (70 End Term Practical + 30 Sessional Practical)

Interpretation of bathymetric maps (Recognition of ridges, trenches, seamounts, abyssal plains, etc.); Identification of continental margins (active v/s passive) and **interpretation** of Indian ocean map; Identification of Sea slope sedimentation and biological Zones; Identification of Costal morphology.

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B.Sc. UG with Honours; Semester VIII
Major Subject (MJ-05-UGH)/Igneous & Metamorphic Petrology
Total Credits-05; Total marks 100 (70 End Term Theory+30 Sessional Theory)

Unit-I: Magmatic differentiation – mechanisms and effects, magmatic crystallization – Bowen's reaction principle, Texture and structures, classification of igneous rocks (only IUGS), granite and other granitoid rocks and ophiolite

Unit-II: Gibbs phase rule, component, and degree of freedom, application of Phase rule in bi-component and tri-component magma; crystallization of bi - and tri -component magma (An-Al-Di system and An- Di – Fo, system).

Unit-III: Petrogenesis and petrography of the following rocks: Aplite, Anorthosite, Andesite, Basalt, Carbonatite, Charnockite, Diorite, Dunite, Dacite, Dolerite, Foidolite, Gabbro, Granite, Granodiorite, Hornblendite, Ijolite, Kimberlite, Komatiite, Lamprophyre, Monzonite, Pegmatite, Phonolite, Peridotite, Syenite, Trachyte.

Unit-IV: Metamorphic process, agents, grade and type of metamorphism, Metamorphic zones and Facies, Metamorphic structure and fabrics, Metamorphic differentiation.

Books recommended

1. Gupta, A.K. (1998): Igneous Rocks Allied Publishers Ltd., New Delhi.
2. Jackson: Textbook of lithology.
3. Winter, J.D. (2001): An Introduction to Igneous and Metamorphic Petrology
4. McBirney, A.R. (1984): Igneous Petrology, Freeman Cooper & Co. California.
5. Phillpots A.: Introduction to igneous and metamorphic petrology, Prentice Hall Pub.
6. Turner, F.J. & Verhoeven, J.: Igneous & Metamorphic petrology CBS Publications.
7. Bose, M.K. (1997): Igneous Petrology, World Press, Kolkatta.
8. Best, Myron G. (2002): Igneous and Metamorphic Petrology, Blackwell Science

B.Sc. UG with Honours; Semester VIII
Major Subject (MJ-06-UGH)/Mineral Exploration & Mining Geology
Total Credits-05; Total marks 100 (70 End Term Theory+30 Sessional Theory)

Unit-I: Mineral Prospecting and Exploration - Prospecting and Stages of mineral exploration: reconnaissance to feasibility, Geological, geophysical and geochemical methods, Role of hyperspectral remote sensing in Mineral exploration.

Unit-II: Ore Reserve Estimation - Sampling techniques and resource evaluation, Classification of mineral resources and reserves, Grade estimation methods: geostatistics and interpolation.

Unit III: Mining Methods - Surface mining: open-pit and strip mining, Underground mining with special reference to coal mining.

Unit- IV: Mining process and Environmental issues - Environmental impacts of mining and mitigation measures, Mining cycle and reclamation practices, Mining Policies and regulations in India.

Books Recommended:

1. Introduction to Mineral Exploration by Charles J. Moon, Michael K.G. Whateley, and Anthony M. Evans; A key resource on exploration techniques and mineral resource assessment.
2. Economic Geology: Principles and Practice by Walter L. Pohl; Provides insights into the economic significance of mineral deposits and mining practices.

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3. Ore Deposit Geology by John Ridley; Focuses on the processes behind ore deposit formation and their exploration.
4. Mining Geology by Hugh Exton McKinstry; A foundational text on mining methods, resource estimation, and exploration strategies.
5. Applied Mining Geology by Marat Abzalov; Covers real-world techniques for resource evaluation and modeling in mining geology.
6. Geochemistry in Mineral Exploration by Herbert Edwin Hawkes and John S. Webb; Discusses the application of geochemical methods in locating mineral deposits.
7. Ore Geology and Industrial Minerals: An Introduction by Anthony M. Evans; Explores ore deposit formation and the geology of industrial minerals.
8. Handbook of Gold Exploration and Evaluation by Eoin MacDonald; Provides specific methods for gold exploration and evaluation techniques.

B.Sc. UG with Honours; Semester VIII
Major Subject (MJ-07-UGH)/Sedimentology
Total Credits-05; Total marks 100 (70 End Term Theory+30 Sessional Theory)

Unit-I: Process of sedimentation, structure, texture and general classification of sedimentary rocks, depositional environment, sedimentary facies, provenance and paleocurrent.
Unit-II: Sedimentary basins and their classification, basin analysis (Map, Cross-sections, Petro-facies, Geological history, Application.
Unit-II: Plate tectonics and sedimentation (sedimentation- divergent margins, convergent and transform margins)
Unit-IV: Petrography of Clastic and non-Clastic rocks.

Books recommended:

1. Pettijohn, F. J. Sedimentary rocks (McGraw-Hill, New Delhi.
2. Verma, V. K. & Prasad, C., Sedimentology (Harman Publ. House, New Delhi).
3. Folk, R. L. Petrology of sedimentary rocks, Hemphill's, Austin, Texas.
4. Blatt, H., Midleton, G and Murray, R., Origin of Sedimentary Rocks, Prentice Hall.
5. Reineck, H.E., & Singh, I. B., Depositional Sedimentary Environments, Springer. N.Y.
6. Best, Myron G., Igneous & Metamorphic Petrology (C B S Publishers, New Delhi).
7. Blatt, Harvey; Tracy, Robert J.; Owens, Brent (2005), Petrology: igneous, sedimentary, and metamorphic (New York: W. H. Freeman).

B.Sc. UG with Honours; Semester VIII
Major Practical (MJ-08-UGH)/(MJ05+MJ06+MJ07)
Total Credits-05; Total marks 100 (70 End Term Pracrical + 30 Sessional Practical)

Mineral Exploration & Mining Geology (20+10)

- Interpretation of exploration data.
- Study of ore in hand specimens.
- Calculation of ore grade and reserve estimation

Igneous & Metamorphic Petrology (30+10)

- Study of important igneous & metamorphic rocks in thin sections and in hand specimen: Anorthosite, Andesite, Basalt, Carbonatite, Charnockite, Diorite, Dunite, Dacite, Dolerite, Gabbro, Granite, Kimberlite, Komatiite, Lamprophyre, Monzonite, Pegmatite, Phonolite, Peridotite, Syenite, Trachyte, Shale, Slate, Phyllite, Schist, Quartzite, Gneiss.

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- NORM calculation.
- Plotting of modal data in IUGS classification diagram for plutonic rocks (Streckeisen diagram)

Sedimentology (20+10)

- Sedimentary rocks in hand specimen and thin sections
- Size and shape analysis
- Heavy mineral identification
- Paleocurrent analysis

B.Sc. UG with Honours; Semester VIII
Major Elective-02 (MJE-02-UGH)/Natural Hazards
Total Credits-04; Total marks 100 (70 End Term Theory+30 Sessional Theory)

Unit-I: Definition and Types of Natural Hazards; Geological, Atmospheric and Other natural hazards.
Unit-II: Processes Involved in Natural Hazards; Vulcanism, Crustal deformation, Isostatic Adjustment, Weathering, Erosion and Atmospheric circulation.
Unit-III: Primary, Secondary and Tertiary effects of Natural Hazards. Disaster Risk Reduction.
Unit-IV: Awareness, Policies and Remedial Measures.

Books Recommended:

1. K. S. Valdiya:- Environmental Geology, Indian Context.
2. E. A. Keller: - Environmental Geology.
3. P. T. Flawn:- Environmental Geology
4. K.S. Valdiya :- Dynamics Himalaya

B.Sc. UG with Honours; Semester VIII
Minor Subject (MI-2A-UGH)/Palaeoclimatology
Total Credits-04

Theory Credits: 02 (70 End Term Theory+30 Sessional Theory)

Unit-I: Elements of weather and climate: Definition of weather, climate, and climate variability, Components of the climate system: atmosphere, hydrosphere, cryosphere, lithosphere, biosphere.
Unit-II: Evidence of climate change (temperature rise, melting glaciers, sea-level rise), Impacts on ecosystems, biodiversity, and species migration, impacts on water resources, agriculture, and food security, use gases and the greenhouse effect.
Unit-III: Observation of climate changes in India, Impact on monsoon systems, Sea-level rise and coastal hazards, Climate change and natural disasters (floods, droughts, cyclones).
Unit-IV: Historical Climate variability (glacial-interglacial cycles, Holocene changes), tools to study past climate: ice-cores,tree rings, sediment cores, fossils.

Books recommended:

1. Houghton, J. (2015): Global Warming: The Complete Briefing. Cambridge University Press.
2. McMichael, A. (2017): Climate Change and Human Health. WHO Publication.
3. Shukla, P.R. et al. (2003): Climate Change and India: Vulnerability & Adaptation. Universities Press.
4. D.S. Upadhyay (1995): Cold Climate Hydrometeorology.

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Practical Credits: 02 (70 End Term Practical + 30 Sessional Practical)

Identification of paleoclimate archives, exercise on sediment core logging; Pollen analysis (demonstration or microscope) – identification, counting, pollen diagram concept: isotope data – interpretation of $\delta^{18}O$ and $\delta^{13}C$ from lake/speleothem/ice core records; LOI, magnetic susceptibility, elemental data interpretation

B.Sc. UG Honours Semester VIII
Minor Subject (MI-2B-UGH)/Himalayan Geology
Total Credits-04

Theory Credits: 02 (70 End Term Theory +30 Sessional Theory)

Unit-I: Introduction, Physiography and origin of Himalaya
Unit-II: Geographical Geological classification of Himalaya
Unit-III: Detailed geology of Lesser, Middle and Upper Himalaya
Unit-IV: Various tectonic boundaries and major geological features of Himalaya

Books Recommended:

1. Valdiya, K.S. (1998): Dynamics of the Himalaya. University Press, India.
2. Gupta, H.K. (2002): The Himalayan Geology. Unwin Hyman, London.
3. Jain, S. & Gansser, A. (2004): Tectonics of the Himalayan Belt. Springer.
4. Gansser, A. (1964): Geology of the Himalayas. Interscience Publishers, New York.

Practical Credits: 02 (70 End Term Practical + 30 Sessional Practical)

Preparation of litho-tectonic map of the Himalaya; Identification of sedimentary basins and metamorphic belt of the Himalayan terrain; plotting of major Earthquakes occurred in the Indian Himalayan region; Using the toposheets, plots the various landforms and neotectonic features.

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B.Sc. UG Honours with Research; Semester VII
Major Subject (MJ-01-UGHR)/Geohydrology
Total Credits-05; Total marks 100 (70 End Term Theory+30 Sessional Theory)

Unit-I: Origin, occurrence, and distribution of groundwater, hydrological cycle, hydrological properties of rocks, water table fluctuations, springs, groundwater provinces of India.
Unit-II: Theory of groundwater flow, Darcy's law - its application and limitation, permeability determination, types of well - unconfined, confined
Unit-III: Groundwater quality - physical and chemical properties, problems of arsenic and fluorides, groundwater contaminations.
Unit-IV: Geophysical methods of groundwater exploration - electrical (resistivity), seismic, gravity methods, groundwater problems and management, artificial recharge, groundwater legislation,

Books recommended:

1. Bouver, H. (1978): Groundwater Hydrology, McGraw Hill.
2. Fetter, C.W. (1990): Applied Hydrogeology, CBS Pub. New Delhi.
3. Todd, D.K. (19880: Ground Water Hydrology, John Wiley & Sons, New York.
4. Davies, S.N. and Dc-West, R.J.N. (1966): Hydrology, John Wiley & Sons, New York.
5. Raghunath, H.M. (1983): Ground Water, Wiley Eastern Ltd. Calcutta.

B.Sc. UG Honours with Research; Semester VII
Major Subject (MJ-02-UGHR)/Structure and Tectonics
Total Credits-05; Total marks 100 (70 End Term Theory+30 Sessional Theory)

Unit-I: Stress and strain relationship of elastic, plastic and viscous materials, factors affecting the behaviour of rocks, kinematic analysis, Mohr's Circles, strain and stress ellipsoids. Measurement of strain in deformed rocks.
Unit-II: Classifications and mechanics of folds, faults, joints, unconformities, boudins, cleavage, lineation, foliation.
Unit-III: Concept of Plate Tectonics, tectonic history of India and origin of Himalaya. Major tectonic features of the oceanic and continental crusts. Seismotectonics/geodynamics of Indian plate.
Unit-IV: Mid oceanic ridges, Deep Sea tranches, Paleo-magnetism, Sea floor spreading, Island arcs, Oceanic islands and Volcanic arcs.

Books Recommended:

1. Davies, A.Z.: Structural Geology.
2. Ghosh, S. K.: Structural Geology, Fundamental and Modern Concepts, Pergamon Press.
3. Ramsay J. G. (1967): Folding and fracturing of Rocks, McGraw Hill Pub.
4. Ramsay J.G. & Huber M. I. (1983, 1987): The Techniques of Modern Structural Geology-I & II, Strain Analysis, Academic Press.
5. Hobbs, B.E., Means, W.D. & Williams, P.F. (1976): An outline of Structural Geology, John Wiley and Sons publ.
6. Turner, F.J. & Weiss, L.E. (1963): Structural analysis of Metamorphic Tectonites, McGraw Hill publ.
7. Condie Kent, C. (1989): Plate Tectonics and Crustal Evolution.
8. W. J. Kious & Robert I.T.: This dynamic of Earth: the story of Plate Tectonics USGS

21/5/25
Head
Department of Geology
H.N.B. Garhwal University
Srinagar (Uttarakhand) 246174

21/5/25
Dean
School of Earth Science
H.N.B. Garhwal University
(A Central University)
Srinagar (Garhwal)-246174
Uttarakhand

publ.
9. Moores, E. & Twiss, R.J., 1995: Tectonics. Freeman publ.
10. Keary, P. & Vine, F.J. 1990: Global Tectonics. Blackwell scientific publ.
11. Valdiya, K.S. 1998: Dynamics Himalaya. Univ. Press.

B.Sc. UG Honours with Research; Semester VII
Major Practical (MJ-03-UGHR)/(MJ01+MJ02)
Total Credits-05; Total marks 100 (70 End Term Practical +30 Sessional Practical)

Geohydrology (35+15)

- Delineation of hydrological boundaries on water table, permeability estimation.
- Analysis of hydrographs and estimation of infiltration capacity.
- Estimation and interpretation of TDS
- Exercise on ground water exploration using remote sensing techniques.

Structure and Tectonics (35+15)

- Preparation and interpretation of geological maps and sections
- Exercises on strain measurements
- Study of various tectonic models
- Stereographic presentation of structural data

B.Sc. UG Honours with Research; Semester VII
Major Elective (MJE-01-UGHR)/Remote Sensing and GIS
Total Credits-04; Total marks 100 (70 End Term Theory+30 Sessional Theory)

Unit I: Fundamental concepts of Remote Sensing; applications in geosciences
Unit II: Aerial photography, photogrammetry concepts, and remote sensing Satellites
Unit III: Visual interpretation of aerial photo/satellite images: Photo-recognition elements.
Unit IV: Fundamentals of Geographical Information System (GIS).

Books Recommended:

1. F.F. Sabine; Remote Sensing- Principals and Interpretation
2. Lillesand R. M. and Kiefer R.W.: Remote Sensing and Image Interpretation
3. R. P. Gupta: Remote Sensing
4. Demers, M. N.: Fundamentals of Geographic Information Systems
5. Bonham Carter G. F.: Fundamentals of Geographic Information Systems for Geoscientists

B.Sc. UG Honours with Research; Semester VII
Major Subject (MJ-04-UGHR)/Research Methods in Geology
Total Credits-05; Total marks 100 (70 End Term Theory+30 Sessional Theory)

Unit-I: Fundamentals of scientific research; types of research; identification and definition of research problem; assessing a research problem; review of literature; Research plan and its components; significance and national & international status of research in geology.
Unit-II: Basic concepts of research design; principles of experimental design; Methods of research (Survey, observation, case studies, experimental, historical and comparative methods); types of data; methods of data collection; sampling; processing and analysis of data and

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interpretation.

Unit-III: Basic mathematical and statistical tool; correlation and regression; trend surface analysis; principal component analysis (PCA) and its use in geological research; test of significance: z- test, t-test, F-test, chi-square (χ^2) test

Unit-IV: Fundamentals of computer; operating system (Windows, LINUX); common application software; open-source software; application software used in geology: (for bivariant, multivariant, log-probability plots, plotting geochemical, structural and hydrogeological data for preparation of litholog and correlation).

Books Recommended:

1. Yogesh Kumar Singh, Fundamental of Research Methodology and Statistics, New Age Publications
2. Kitsakorn Locharoenrat, Research Methodologies for Beginners, CRC Press
3. Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, Sage Publications
4. C. R. Kothari, Research Methodology: Methods and Techniques, New Age Publications, 2009
5. J. C. Davis, Statistics and Data Analysis in Geology, Wiley India, 2002
6. Subhash Chandra Parija and Vikram Kate, Thesis Writing for Master's and Ph.D. Program, Springer
7. Patrick Dunleavy and Palgrave Macmillan, Authoring a PhD: How to Plan, Draft, Write and Finish a Doctoral Thesis or Dissertation
8. Carol Ellison, McGraw-Hill's Concise Guide to Writing Research Papers, McGraw-Hill
9. John W. Creswell, Research Design: Qualitative, Quantitative, and Mixed Method Approaches, Sage Publications
10. Peter Pruzan, Research Methodology: The Aims, Practice and Ethics of Science, Springer
11. Philips E M & Pugh D.S., How to get a Ph D, UBS publishers & Distributors, New Delhi, 1998
12. Rajendra Naragundkar, Marketing Research, Text and Cases, Mc Graw Hill, 2008

B.Sc. UG Honours with Research; Semester VII
Minor Subject (MI-01A-UGHR)/Environmental Geology
Total Credits-04

Theory: 02 Credits (70 End Term Theory+30 Sessional Theory)

Unit-I: Introduction to environmental geology, its fundamental concepts, and scope

Unit-II: Environmental ethics; Ecosystem Concepts (atmosphere, hydrosphere, lithosphere and biosphere)

Unit-III: Soil erosion; land resources, natural hazards; depletion of water resources: causes and impact;

Unit-IV: Renewable and non- renewable sources of energy; hydrological cycle, carbon cycle, concept of climate change.

Books Recommended:

1. K. S. Valdiya:- Environmental Geology, Indian Context.
2. E. A. Keller: - Environmental Geology.
3. P. T. Flawn:- Environmental Geology.
4. D. Howard and I. Remson: - Geology in Environmental Planning.

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Practical: 02 Credits (70 End Term Practical + 30 Sessional Practical)

Evaluation of environmental impact of air pollution and groundwater pollution; identification of natural disaster sites based on topographic and geological maps; identification of renewable and non- renewable sources of energy in the context of India.

B.Sc. UG Honours with Research; Semester VII
Minor Subject (MI-01B-UGHR)/Marine Geology
Total Credits-04

Theory: 02 Credits (70 End Term Theory+30 Sessional Theory)

Unit-I: Ocean Basins and Tectonics - Origin and classification of ocean basins, Sea-floor spreading, mid-ocean ridges, and plate tectonics.

Unit-II: Marine Sedimentation and Coastal Processes - Types of marine sediments: terrigenous, biogenic, and hydrogenous, Brief introduction of Sediment transport and deposition in coastal and deep-sea environments, Ocean circulation and impact of climate change.

Unit III: Coastal geomorphology and Paleoceanography - Sea level changes; Coastal geomorphology: beaches, dunes, and estuaries, Paleoceanographic archives: sediments, corals, and foraminifera.

Unit IV: Marine Resources - Economic resources: polymetallic nodules, gas hydrates, and hydrocarbons., Environmental impacts of marine mining, Coastal zone management and marine pollution.

Books Recommended:

1. Marine Geology by James P. Kennett; A comprehensive introduction to marine sediments, plate tectonics, and seafloor processes.
2. Marine Geology by Jon Erickson; Covers diverse marine geological topics, including oceanic ridges, trenches, and deep-sea exploration.
3. Seafloor Geomorphology as Benthic Habitat by Peter Harris and Elaine Baker Focuses on seafloor mapping and its applications in marine conservation and geology.
4. Geological Oceanography by Fran k J. P. Veizer; Explores marine geological processes with an emphasis on ocean chemistry and sedimentology.
5. Marine Geology: Exploring the New Frontiers of the Ocean by Roger N. Anderson; Discusses advanced research and cutting-edge exploration technologies.
6. The Oceans and Marine Geology & quote; by Trujillo and Thurman; An introductory textbook combining oceanography with geological processes.
7. Climate and Marine Cycles by John G. Anderson; Connects marine geological processes with climate evolution over geological timescales.
8. Ocean Circulation and Sedimentation by Cesare Emiliani; Examines the interplay between ocean currents and sedimentation patterns.

Practical: 2 Credits (70 End Term Practical + 30 Sessional Practical)

Interpretation of bathymetric maps (Recognition of ridges, trenches, seamounts, abyssal plains, etc.); Identification of continental margins (active v/s passive) and **interpretation** of Indian ocean map; Identification of Sea slope sedimentation and biological Zones; Identification of Costal morphology.

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Uttarakhand

B.Sc. UG Honours with Research; Semester VIII
Major Subject (MJ-05-UGHR)/Igneous & Metamorphic Petrology
Total Credits-05; Total marks 100 (70 End Term Theory+30 Sessional Theory)

Unit-I: Magmatic differentiation – mechanisms and effects, magmatic crystallization – Bowen's reaction principle, Texture and structures, classification of igneous rocks (only IUGS), granite and other granitoid rocks and ophiolite

Unit-II: Gibbs phase rule, component, and degree of freedom, application of Phase rule in bi-component and tri-component magma; crystallization of bi - and tri -component magma (An-Al-Di system and An- Di – Fo, system).

Unit-III: Petrogenesis and petrography of the following rocks: Aplite, Anorthosite, Andesite, Basalt, Carbonatite, Charnockite, Diorite, Dunite, Dacite, Dolerite, Foidolite, Gabbro, Granite, Granodiorite, Hornblendite, Ijolite, Kimberlite, Komatiite, Lamprophyre, Monzonite, Pegmatite, Phonolite, Peridotite, Syenite, Trachyte.

Unit-IV: Metamorphic process, agents, grade and type of metamorphism, Metamorphic zones and Facies, Metamorphic structure and fabrics, Metamorphic differentiation.

Books recommended

1. Gupta, A.K. (1998): Igneous Rocks Allied Publishers Ltd., New Delhi.
2. Jackson: Textbook of lithology.
3. Winter, J.D. (2001): An Introduction to Igneous and Metamorphic Petrology
4. McBirney, A.R. (1984): Igneous Petrology, Freeman Cooper & Co. California.
5. Phillpots A.: Introduction to igneous and metamorphic petrology, Prentice Hall Pub.
6. Turner, F.J. & Verhoeven, J.: Igneous & Metamorphic petrology CBS Publications.
7. Bose, M.K. (1997): Igneous Petrology, World Press, Kolkatta.
8. Best, Myron G. (2002): Igneous and Metamorphic Petrology, Blackwell Science

B.Sc. UG Honours with Research; Semester VIII
Major Practical (MJ-06-UGHR)
Total Credits-03; Total marks 100 (70 End Term Pracrical + 30 Sessional Practical)

Igneous & Metamorphic Petrology (70+30)

- Study of important igneous & metamorphic rocks in thin sections and in hand specimen: Anorthosite, Andesite, Basalt, Carbonatite, Charnockite, Diorite, Dunite, Dacite, Dolerite, Gabbro, Granite, Kimberlite, Komatiite, Lamprophyre, Monzonite, Pegmatite, Phonolite, Peridotite, Syenite, Trachyte, Shale, Slate, Phyllite, Schist, Quartzite, Gneiss.
- NORM calculation.
- Plotting of modal data in IUGS classification diagram for plutonic rocks (Streckeisen diagram)

B.Sc. UG Honours with Research; Semester VIII
Elective Course (MJE-02-UGHR)/Natural Hazards
Total Credits-04; Total marks 100 (70 End Term Theory+30 Sessional Theory)

Unit-I: Definition and Types of Natural Hazards; Geological, Atmospheric and Other natural hazards.

Unit-II: Processes Involved in Natural Hazards; Vulcanism, Crustal deformation, Isostatic Adjustment, Weathering, Erosion and Atmospheric circulation.

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Unit-III: Primary, Secondary and Tertiary effects of Natural Hazards. Disaster Risk Reduction.
Unit-IV: Awareness, Policies and Remedial Measures.

Books Recommended:

1. K. S. Valdiya:- Environmental Geology, Indian Context.
2. E. A. Keller: - Environmental Geology.
3. P. T. Flawn:- Environmental Geology
4. K.S. Valdiya :- Dynamics Himalaya

B.Sc. UG Honours with Research; Semester VIII
Major Subject (MJ-07-UGHR)/ Dissertation
Total Credits-12; Total marks 100 ((70 End Term Theory +30 Sessional)

Students will carry a 12 credits dissertation in geology typically involves in-depth research on a specific topic within the field of earth science. The departmental committee will provide the topic and supervisor to the students. The student will also involve in the process of finalisation of the topic of dissertation. However, it will depend on the facilities and expertise available in the department. The decision of departmental committee will be final in this process. The candidate has to submit a dissertation thesis to the department which will be evaluated by the external expert followed by the viva voce.

B.Sc. UG Honours with Research; Semester VIII
Minor Subject (MI-2A-UGHR)/Palaeoclimatology
Total Credits-04

Theory Credits: 02 (70 End Term Theory+30 Sessional Theory)

Unit-I: Elements of weather and climate: Definition of weather, climate, and climate variability, Components of the climate system: atmosphere, hydrosphere, cryosphere, lithosphere, biosphere.
Unit-II: Evidence of climate change (temperature rise, melting glaciers, sea-level rise), Impacts on ecosystems, biodiversity, and species migration, impacts on water resources, agriculture, and food security, use gases and the greenhouse effect.
Unit-III: Observation of climate changes in India, Impact on monsoon systems, Sea-level rise and coastal hazards, Climate change and natural disasters (floods, droughts, cyclones).
Unit-IV: Historical Climate variability (glacial-interglacial cycles, Holocene changes), tools to study past climate: ice-cores,tree rings, sediment cores, fossils.

Books recommended:

1. Houghton, J. (2015): Global Warming: The Complete Briefing. Cambridge University Press.
2. McMichael, A. (2017): Climate Change and Human Health. WHO Publication.
3. Shukla, P.R. et al. (2003): Climate Change and India: Vulnerability & Adaptation. Universities Press.
4. D.S. Upadhyay (1995): Cold Climate Hydrometeorology.

Practical Credits: 02 (70 End Term Practical + 30 Sessional Practical)

Identification of paleoclimate archives, exercise on sediment core logging; Pollen analysis (demonstration or microscope) – identification, counting, pollen diagram concept;: isotope data – interpretation of $\delta^{18}O$ and $\delta^{13}C$ from lake/speleothem/ice core records; LOI, magnetic susceptibility, elemental data interpretation.

Head 21/5/25
Department of Geology
H.N.B. Garhwal University
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Dean 27/5/25
School of Earth Sciences
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(A Central University)
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Uttarakhand

B.Sc. UG Honours with Research; Semester VIII
Minor Subject (MI-2B-UGHR)/Himalayan Geology
Total Credits-04

Theory: 02 Credits (70 End Term practical +30 Sessional)

Unit-I: Introduction, Physiography and origin of Himalaya,
Unit-II: Geographical and Geological classifications of Himalaya
Unit-III: Detailed geology of Outer, Lesser, Middle and Tethys Himalaya
Unit-IV: Various tectonic boundaries and major geological features of Himalaya

Books Recommended:

5. Valdiya, K.S. (1998): Dynamics of the Himalaya. University Press, India.
6. Gupta, H.K. (2002): The Himalayan Geology. Unwin Hyman, London.
7. Jain, S. & Gansser, A. (2004): Tectonics of the Himalayan Belt. Springer.
8. Gansser, A. (1964): Geology of the Himalayas. Interscience Publishers, New York.

Practical Credits: 02 (70 End Term Practical + 30 Sessional Practical)

Preparation of litho-tectonic map of the Himalaya; Identification of sedimentary basins and metamorphic belt of the Himalayan terrain; plotting of major Earthquakes occurred in the Indian Himalayan region; Using the toposheets, plots the various landforms and neotectonic features.

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Uttarakhand