Course title: Glacier hydrology			
Course code: NRE 136	**No. of credits:** 3	**L-T-P:** 22-0-40	**Learning hours:** 42
Pre-requisite course code and title (if any): Students are expected to have fundamental know1edge of hydrology and issues related to climate change. The course work involves intensive field work in high altitude remote locations; the candidates should be physically fit to carry out the field work in harsh conditions			
Department: Energy and Environment			
Course coordinator(s):		**Course instructor(s):** Dr Shresth Tayal	
Contact details: stayal@teri.res.in			
Course type: Elective		**Course offered in:** Semester 3	

Course description

The hydrology of glacierised regions is thermally controlled. Runoff results from interaction of precipitation with environmental thermodynamics. Variations in energy availability lead to fluctuations in melting of snow and ice and production of meltwater. Seasonal variations in the form of precipitation from winter snowfall to summer rain and energy supply peaking to a summer maximum produce strong seasonal periodicity of hydrological event, which influences quantity, quality as well as timing of drainage.

Course objectives

- To acquaint students with the fundamentals of glacier science, glacier environment and significance of glaciers in regulating water availability.
- To understand the basic concepts about flow variations in proglacial streams feeding to hydropower plants in Himalayas.
- To encourage and motivate students for advanced glacier research

Course content

Module	Topic	L	T	P
1.	**Fundamental Principles** Glaciers and the Water cycle-Basic concepts of glaciology, glaciers and the atmospheric-hydrospheric Environment. The role of snow and Ice-abundance of water ice and snow, water circulation, the role of snow and ice in global environment Flow of Ice: Flow law for ice, rate limiting processes, variations in rheology, ice deformation, basal flow of ice, stress and velocity distribution in an idealized glacier	2 4		4
2.	**Snowmelt Processes** Melt processes at the glacier surface-Computation of melt rate, physical process, energy balance approach, empirical approach and rain on snow cover and glaciers, runoff delay from glacier melt, water balance of a snow cover area. Seasonal snow cover-formation, nature, properties and variations in snow cover, snow density and its variations. Dye tracer investigation: Distributed and Channelized Flow. Time lag in discharge Hydrograph Separation-Electrical Conductivity measurements, EC-Discharge relationships, Hydrograph separations using EC and Sulphate as marker. Glacial Hydrological System-meltwater system, supraglacial, englacial and subglacial hydrological systems. Rainfall-runoff,	4 2 2 2		4 4 8

	snowmelt and ice melt modeling.			
3.	**Glacier Hydrochemistry** Glacial Hydrochemistry-chemical properties of melt water, process of solute acquisition, sources of cations and anions, dominant reactions responsible for solute acquisitions in meltwater, Controls on solute fluxes, dissolved load-discharge relationship	2		4
	Techniques in Glacier Research Principles of mass balance; Methods to determine mass balance; Calculation of Mass Balance GPS and its applications in Glacier Research, Data corrections and validation, Transformation into GIS platform and analysis	2 2		8 8
	Total	**22**		**20**

Evaluation criteria

- Test 1: 15%
- Test 2: 15%
- Field work and report: 30%
- Test 3: 40%

Learning outcomes

- An understanding on interdisciplinary aspects of high altitude research.
- An understanding about the tools and techniques to conduct research on glaciers
- An exposure to glacier environment

Pedagogical approach

Materials

Required text

1. Hasnain S.I. (1999) *Himalayan Glaciers: Hydrology and Hydrochemistry*, Allied Publishers Limited, New Delhi.
2. Upadhyay D.S. (1995) *Cold Climate Hydrometeorology*, New Age International (P) Publishers Limited, New Delhi.

Suggested readings

1. Sharp M., Keith S.R. and Tranter M. (Editors) (1998) *Glacier Hydrology and Hydrochemistry*, Wiley Publication.
2. Singh P. and Singh V.P. (2001) *Snow and Glacier Hydrology*, Kluwer Academic Publishers, PO Box 989, 3300 AZ Dordrecht, The Netherlands.
3. Singh S. (1993) *Physical Geography*, PrayagPustakBhawan, Allahabad.
4. Young G.J. (editor) (1994) *Snow and Glacier Hydrology*, IAHS Publication.

Field work

Journals

1. Hydrological Sciences
2. Journal of Geophysical Research
3. Journal of Glaciology

Additional information (if any)

Student responsibilities

Attendance, feedback, discipline, guest faculty etc.

Course Reviewers

The course is reviewed by the following experts.

1. Prof. Helgi Bjornsson, Research Professor of Glacierlogy, Institute of Earth Sciences, University of Iceland, Reykjavik, Iceland
2. Prof. David Collins, Department of Geography, University of Salford, Manchester, U.K.
3. Dr Gwyn Rees, Head Glacier Hydrology, Institute of Ecology and Hydrology, U.K.