DETAILED SCHEDULE
PRINCIPLES OF HYDROLOGY 2024
Geography 827.3
Professor John Pomeroy,
Centre for Hydrology and Dept. of Geography & Planning, University of Saskatchewan

Contact Hours and Schedule

Lectures will be held in an intensive 11-day period at the Biogeoscience Institute, Barrier Lake Field Station, Kananaskis Valley, Alberta starting on the morning of Thursday, 31 October 2024 (arrive 30 October). Lectures will be up to three 90 min. sessions per day. Lectures begin 0830h on 31 October and end at 4:00 pm, 10 November. There is a break from 1000h to 1030h and lunch is at 1200h. Afternoon lectures resume at 1330h with completion generally by 1500h. Dr. Pomeroy and a CWRA representative will be available on site during the course and by email afterwards, individual instructors will be available for portions of the course corresponding to their lecture day and at least one other day. The 2-hour final exam will take place in person on Nov 11th at 0900h on site. There will be three outdoor laboratory sessions, and an evening instrumentation session at the Coldwater Laboratory in Canmore.

i) An instrumented site visit to Marmot Creek Research Basin, Kananaskis on 3 November in the afternoon.
ii) A demonstration of sensors and dataloggers at the Coldwater Laboratory on 6 November in the early evening.
iii) A demonstration of snow surveying techniques at a high elevation pass on the afternoon of 7 November.
iv) A demonstration of hydrometry at a stream gauge site and hydroelectricity facility on the nearby Kananaskis River on 9 November.

These outdoor laboratories are in remote mountain locations but near to roads, they do not have avalanche risks and do not require more than normal physical fitness and outdoor awareness. The site at Marmot Creek Research Basin will be a 15 min walk in from the bus along a level trail at 1400 m elevation. The stream gauge site is 15 min walk with a small hill from the Barrier Lake Field station. The snow survey site is next to a road and involves walking in snow and working with snow survey equipment outdoors in sometimes chilly conditions The forecast for these sites can be found here http://www.mountain-forecast.com/peaks/The-Fortress/forecasts/2000 , http://weather.gc.ca/city/pages/ab-42_metric_e.html and current weather conditions from our weather stations can be found here https://research-groups.usask.ca/hydrology/data.php.

Date	Subject	Instructor
31 Oct	**Fundamentals & Hydrological Cycle Hydrometeorology & Precipitation** -Essay Assignment	John Pomeroy
1 Nov	**Snow Accumulation, Sublimation & Redistribution** **Advances in Understanding Snow Interception**	John Pomeroy Alex Cebulski
2 Nov.	**Groundwater Hydrology** -Assignment 1	Ed Cey
3 Nov.	**Interception & Evapotranspiration** -Assignment 2 **Instrumented Basin Visit –** Marmot Creek (bus)	Richard Petrone John Pomeroy
4 Nov.	**Snowmelt and Snowcover Depletion**	John Pomeroy
5 Nov.	**Glaciers** - Assignment 3	John Pomeroy
6 Nov.	DAY OFF -Sensors at the Coldwater Laboratory – (bus to and from Canmore)	 John Pomeroy,
7 Nov.	**Soil Hydrology** **Snow Surveying**– Highwood Pass (bus)	Andrew Ireson John Pomeroy
8 Nov.	**Hillslope and Catchment Hydrology** -Assignment 4	Sean Carey
9 Nov	**River Basin Hydrology and Streamflow Hydrographs** **Hydrometry and the Water Survey of Canada** **Stream Gauging** –Kananaskis River demonstration (walk)	Kevin Shook Matt Falcone Matt Falcone
10 Nov	**Hydraulics, Routing and River Ice** **Synthesis** - Assignment 5	Tricia Stadnyk John Pomeroy
11 Nov	**Final Examination**	John Pomeroy

If you have medical issues that will affect you on these field trips please contact Professor Pomeroy to discuss beforehand.

The closed book, short answer final examination (2 hour) will be given onsite at the Barrier Lake Field Station at the end of the course (morning Nov 11th). Exercises and literature review are **due one month after they are assigned** and are submitted electronically to Dr. Pomeroy via the Canvas system.

NOTE: you must work independently and originally in all assignments and examinations, cite appropriately in submitted essay material and follow the University of Saskatchewan Guidelines for Academic Conduct https://governance.usask.ca/documents/student-conduct-appeals/GuidelinesAcademicConduct1999.pdf and Academic Integrity https://academic-integrity.usask.ca/students.php.

Marking and Evaluation

Marks will be
-20% final exam,
-30% literature review on a hydrological process selected in consultation with Dr. Pomeroy
-50% quantitative exercises

i) micrometeorology and evapotranspiration
ii) groundwater hydrology
iii) snow accumulation, glaciers and melt
iv) soil and hillslope hydrology
v) river basin hydrology and hydraulics including river ice

*Non-credit (audit) students **must** complete the quantitative exercises and attend all lectures and field excursions. Those taking the course for university credit **must complete all assignments**, the literature review and the in-person final examination on Nov 11th .*

Contact Information
Professor John Pomeroy john.pomeroy@usask.ca
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or 403 678 0579 (general office phone – emergencies during daytime)
or
Centre for Hydrology, 11 Innovation Blvd, University of Saskatchewan, Saskatoon
306 966 1426
or Joni Onclin in Saskatoon, office 306 966 1427

Detailed Schedule

31 Oct POMEROY Fundamentals, Physical Principles, Hydrometeorology and Precipitation

Welcome and course introduction.

Fundamentals
-Hydrological cycle, hydrological processes
-Units and physical constants for hydrology
-Fick's law, Viscosity, Darcy's law, Ohm's Law, Ideal Gas Law,
-Continuity and control volumes
-Flow of water in a pipe and Bernoulli's Equation
-Mass and energy balances
-Phase change and coupled mass and energy balances.
-Basins, sub-basins and hydrological response units as control volumes

Physical Principles
-Net radiation, including estimation of shortwave direct and diffuse to complex terrain, albedo variations of various surfaces, longwave radiation from the atmosphere and from the surface, measurement
-Ground heat fluxes – heat conduction equation, thermal conductivity, measurement

Turbulent Transfer
-wind flow, turbulence and boundary layers,
- convective heat transfer,
- convective water vapour transfer,
- stability effects.

Precipitation
-Physics of the formation of precipitation in the atmosphere
-Characteristics of frontal, convective and orographic precipitation
-Depth, area and duration of precipitation over an area
-Introduction to the statistical features of precipitation (rainfall)
-Measurement principles
-Precipitation data products

Essay Assignment Assigned.

Readings
-provided papers on Canvas
-Textbook, Dingman, Physical Hydrology 2nd or 3rd Edition. Chapters 1-4, Appendix D
-Supplementary Textbook: The Surface Climates of Canada, W.G. Bailey, T.R. Oke and W.R. Rouse, 1998: Montreal: McGill-Queen's Univ Press. (Available on Amazon)

1 November POMEROY Snow accumulation and redistribution

- Snowcover Properties and Measurement
- Snow Redistribution Processes
    - Wind: saltation, suspension, sublimation, vegetation effects
    - Vegetation: interception, unloading, sublimation
- Snowcover Distribution
    - Open environments
    - Forested environments

Special Lecture – Snow Interception in Forests ALEX CEBULSKI

Readings
-Snowcover Accumulation, Relocation and Management (Pomeroy & Gray)
- provided papers in Canvas
-Dingman, Chapter 5

2 November CEY Groundwater Hydrology

1. Basic principles of groundwater flow and transport
- Porosity and fluid potential
- Darcy's law, hydraulic conductivity, and permeability
- Groundwater flow and velocity
- Groundwater storage
- Basic transport processes

2. Regional groundwater flow
- Groundwater flow systems
- Topography-driven flow
- Scale of flow and effects of heterogeneity
- Computer lab using USGS TopoDrive

3. Groundwater - surface water interactions
- Interactions with streams, wetlands and lakes
- Modelling and measurement methods
- Water resource management – water budgets and groundwater pumping

Reading:
Dingman (Physical Hydrology, 3rd ed., Chapter 9).
Fetter (2001. Applied Hydrogeology, 4th ed., pp.66-109, 190-197, 400-414)
-provided papers in Canvas

Assignment 1 assigned. Groundwater Hydrology

3 November PETRONE Interception and Evapotranspiration

Canopy Interactions
- Intro
- Hydraulic Lift
- Interception
- Gash Model

Methods of Determination
- Direct:
    - Pan / Lysimeter Measurements
    - Gradient / Energy Balance (Bowen Ratio)
    - Eddy Covariance
- Indirect:
    - Thornthwaite
    - Priestley-Taylor
    - Penman – based

Textbook: Campbell and Norman (1998. An Introduction to Environmental Biophysics, 2nd Ed., pp. 37 – 50, 223 – 277)

Assignment 2 Assigned. Hydrometeorology and Evapotranspiration.

Afternoon Instrumented Site Visit: POMEROY

1300h-1530h bus to field site: Instrumented field site visit in afternoon (Marmot Creek Research Basin - Hay Meadow tower, 1400 m elevation, 20 min walk in, level terrain – dress appropriately, it can be windy)

4 November POMEROY Snowmelt and snowcover depletion

- Snowmelt and Energy balance
    - Estimation of radiation and turbulent transfer terms,
    - Effect of vegetation,
    - Snowmelt estimation methods
- Snow covered area, snowmelt contributing area and areal depletion

Readings
-Provided papers in Canvas
-Dingham Chapter 5

5 November POMEROY Glacier Hydrology

Glacier Hydrology
- Ice properties
- The glacier-climate system
- Glacier mass balance
- Global glacier changes
- Canada's glaciers
- Mass balance trends in Canada
- Competing demands for water
- Environment and natural resource considerations
- Glaciers as storage
- Water routing
- Discharge characteristics
- Linear reservoir model approach
- Long-term effect of negative glacier mass balance
- Characterization of basin-wide glacier contribution

Assignment 3 assigned: Snow accumulation, glaciers and melt.

Readings
-provided papers in Canvas

6 November **Day Off**

Evening at the Coldwater Laboratory, Canmore – **-Hydrometeorological and hydrological sensor demonstration and discussion of sensors, including UAVs.**
Chance to visit Canmore. Bus from Field Station 6 pm.

7 November

Morning: IRESON Soil Hydrology

1. Soils and the soil water balance
- Soil texture and mineralogy
- Soil-water; mass volume relations
- Hydrological processes: infiltration, runoff generation, drainage, evapotranspiration

2. Soil physics
- Soil water content and matric potential
- Pressure and hydraulic gradient
- Darcy's equation
- Non-ideal soils: macropores, heterogeneity and other realities

3. Cold regions soil hydrology
- Soil thermal regime
- Freeze-thaw processes and impacts on infiltration

Reading:

- Dingman, S.L. Physical Hydrology (3rd Edition). 2015.; Chapter 7 (Principles of subsurface flow) and 8 (Infiltration and water movement in soils).
  Provided papers in Canvas

Afternoon Snow Survey (POMEROY)

1300h-1700h. Bus to Highwood Pass. Weather permitting. You will be instructed in how to measure snow depth and density using gravimetric snow tubes, snow rulers and snow pit kits. You will work in teams to measure snow water equivalent in a mixture of open and wooded areas and can compare measurement methodologies. Bring appropriate clothing for walking on and digging in snow, taking measurements and standing outside in cold and windy conditions.
(parka, toque, light gloves, heavy gloves, wind pants, snow boots, sun glasses, pencil small note pad)

8 November CAREY Hillslope and Catchment Hydrology

1. Hillslope Hydrology
    a. Historical context
    b. Runoff generation processes
        i. Hydrometric methods and responses
        ii. Hydrochemical methods and responses
    c. Catchment form and function
        i. Topography, topology and typology
    d. The role of storage
        i. Riparian & Hyporheic Zone
        ii. Wetlands
        iii. Depressions
        iv. Lakes

2. Modelling runoff at the hillslope and catchment scale
    a. Conceptual Models
    b. Numerical Models
        i. Empirical Methods
        ii. Physically-Based Methods

Assignment 4 assigned. Soil and Hillslope Hydrology

Reading:
Dingman (2001. Physical Hydrology, 2nd ed. pp. 389-456) or equivalent in new edition
Readings provided in Canvas

9 November SHOOK: River Basin Hydrology

River basins
- Canadian River Basins
- Basin Connectivity
- Prairie Streamflow Generation

Event hydrograph prediction
- -Isochronal analysis
- -Rational method
- -Unit hydrographs
  - -Application
  - -Derivation

Reading:
Dingman Ch. 10
-provided readings in Canvas

FALCONE: Hydrometric Observations and the Water Survey of Canada 1400h

Hydrometry lecture and demonstration of instruments in lecture theatre,

1500h Stream Gauge Field Site Visit (on foot).
To Kananaskis River below Barrier Lake. (Falcone and Pomeroy)

10 January STADNYK, POMEROY Hydraulics, routing, river ice, synthesis

STADNYK: Hydraulics, Routing, River Ice

Open Channel Flow
- Fluid physics
- Classification of flow regime and turbulence
- Hydraulic profiling
- Summary

River Routing
- Physics of flood waves
- Classification of river routing methods
- Governing principles
- Hydrological routing
- Hydraulic routing
- Summary

River Ice Processes
- Ice formation
- Ice thickening
- Ice decay
- River ice breakup
- Ice jams
- Ice-on river hydraulics
- Summary

POMEROY: Synthesis

Cold Regions Hydrological Cycling and Streamflow Generation – synthesis
Discussion of final examination.

Assignment 5 assigned. River basin hydrology, hydraulics and river ice

Readings in Canvas and:
Dingman (2001. Physical Hydrology, 2nd ed. pp. 432-456) or equivalent in new edition
Dingman (2001. Physical Hydrology, 2nd ed.. pp.424-428, 548-551) or equivalent in new edition

11 November Final Examination and Departure

0900-1100h Final Examination for those taking GEOG 827 for University Credit

1200h Departure (no lunch provided)