ENGINEERING HYDROLOGY

ENCE 306

Lecture : 3 **Year : III**
Tutorial : 2 **Part : I**
Practical : 2/2

Course Objectives:
The objective of this course is to provide students the concept of hydrology and meteorology with computational analysis for the design and management of water resources projects using practical approach on the application of hydro-meteorological knowledge to solve engineering problems. After completion of this course students will be able to estimate precipitation, hydrological losses and runoff from a watershed, measure the streamflow and analyze hydrographs, floods and flood routing.

1 Introduction (3 hours)

1.1 Scope and application of engineering hydrology
1.2 Hydrologic cycle and water balance equations
1.3 Development of hydro-meteorological study and data in Nepal
1.4 Delineation of hydrological boundary and its characterization

2 Precipitation (8 hours)

2.1 Causes, forms and types of precipitation
2.2 Rainstorm hydrology
- 2.2.1 Rainfall Measurement: Types, network and adequacy of rain-gauges
- 2.2.2 Preparation of rainfall data: Estimation of missing rainfall data; Test for consistency of record by double mass curve
- 2.2.3 Presentation of rainfall data: Mass curve; Hyetograph; Point rainfall; Moving average annual rainfall graph
- 2.2.4 Cumulative distribution and probability density functions of rainfall
- 2.2.5 Mean rainfall over an area: Arithmetic mean, Thiessen and Isohyets
- 2.2.6 Depth duration (DD), depth area duration (DAD) and intensity duration frequency (IDF) curves
- 2.2.7 Frequency of rainfall; Goodness of fit test (Chi square test)
- 2.2.8 Probable maximum precipitation (PMP)

2.3 Snowstorm hydrology
- 2.3.1 Snow climatology, snow distribution and snowpack condition
- 2.3.2 Snowfall measurement: Snow depth, snow stakes and snow boards
- 2.3.3 Water equivalent of snow: Snow density; snow gauges and tubes
- 2.3.4 Remote sensing of snowpack; Ultrasonic snow depth sensor
- 2.3.5 Snow-melting runoff process; Snowmelt-runoff modeling
- 2.3.6 Changing snowpack and glaciers in a warming world
- 2.3.7 Snow avalanches

3 Abstractions from Precipitation (Hydrological Losses) (6 hours)

- 3.1 Initial losses: Interception and depression storage
- 3.2 Evaporation
  - 3.2.1 Meteorological parameters: Radiation, temperature, vapor pressure, humidity and wind speed
  - 3.2.2 Measurement of evaporation by Evaporimeters
  - 3.2.3 Empirical evaporation equations: Meyer's and Rohwer's formulae
  - 3.2.4 Evaporation estimation by water-budget and energy-budget methods
- 3.3 Evapotranspiration
  - 3.3.1 Actual evapotranspiration and measurement by Lysimeters
  - 3.3.2 Potential evapotranspiration and estimation by Penman's equation
- 3.4 Infiltration
  - 3.4.1 Measurement of infiltration by Infiltrometers
  - 3.4.2 Infiltration models: Horton; Introduction to Kostiakov, Phillip and Green-Ampt
  - 3.4.3 Infiltration indices: Φ and W

4 Surface Runoff (3 hours)

- 4.1 Factors affecting runoff from a catchment
- 4.2 Runoff characteristics of rivers and streams
- 4.3 Rainfall runoff relations
- 4.4 Monthly flows by regional formulae (MIP, WECS and MHSP methods)
- 4.5 Annual runoff hydrograph
- 4.6 Basics of rainfall-runoff modeling

5 Streamflow Measurement (5 hours)

- 5.1 Stream gauging: Site selection for stage and flow measurements
- 5.2 Stage measurement: Staff and wire gauges; Float gauge recorder; Bubble gauge; Radar sensor
- 5.3 Velocity measurement techniques
- 5.4 Streamflow measurement: Velocity area method (Using current meter);
- 5.5 Streamflow measurement through structures (Notches, weirs and flumes)
- 5.6 Streamflow estimation by slope area method
- 5.7 Rating curves: Development (Permanent and shifting control); Extrapolation and application

6 Hydrograph Analysis (8 hours)

- 6.1 Components of a rainstorm hydrograph
- 6.2 Factors affecting shape of rainstorm hydrographs
- 6.3 Separation of base flow
- 6.4 Effective rainfall hyetograph and direct runoff hydrograph
- 6.5 Unit hydrographs: Introduction; Uses and limitations

6.6 Derivation of unit hydrographs from isolated and complex storms
6.7 Derivation of unit hydrographs of different durations (Superposition and the S-curve)
6.8 Synthetic unit hydrograph (Snyder's method)

7 Flood Hydrology (8 hours)

7.1 Design flood and its frequency
7.2 Relation of flood frequency with risk and lifespan of structure
7.3 Design floods in gauged river basins by flood frequency analysis
  7.3.1 Plotting positions and probability distributions for flood prediction
  7.3.2 Flood statistics and frequency factors
  7.3.3 Gumbel extreme value type I distribution
  7.3.4 Log Pearson type III distribution
  7.3.5 Log Normal distribution
  7.3.6 Goodness of fit tests (Chi square test)
7.4 Design floods in ungauged river basins
  7.4.1 Rational method using Mononobe's equation for rainfall intensity
  7.4.2 Rainfall-runoff methods: Snyder, BD Richard and PCJ models
  7.4.3 Regional empirical formulae: Dickens, WECS and MHSP methods
7.5 Flash floods
  7.5.1 Intense rainfall (Cloud outburst; Stationary monsoon troughs; Monsoon depressions)
  7.5.2 Glacial lake and landslide dammed outburst floods
  7.5.3 Impact of climate change on flash floods
7.6 Probable maximum flood (PMF)
7.7 Basics of flood modeling

8 Flood Routing (4 hours)

8.1 Concept of reservoir and channel routing; Basic equations
8.2 Hydrologic channel routing (Prism and wedge storage)
8.3 Muskingum equation and estimation of parameters (K and x)
8.4 Muskingum method of channel routing (Linear reservoir)
8.5 Clark's method for instantaneous unit hydrograph (Time area histogram)

Tutorial (30 hours)

1. Adequacy of rain gauges and estimation of missing rainfall
2. Test for inconsistencies of rainfall data (Double mass curve)
3. Estimation of mean rainfall over an area by 3 methods
4. Construction of depth duration, IDF and DAD curves
5. Frequency analysis of rainfall
6. Goodness of fit tests (Chi squared test)
7. Estimation of evaporation by Meyer's and Rohwer's equations
8. Estimation of PET by Penman's equation
9. Estimation of parameters of Horton's infiltration model

10. Estimation of monthly flows by rainfall-runoff equations and regional methods (MIP, WECS and MHSP)
11. Discharge computation by velocity area using current meter
12. Discharge estimation by slope area method
13. Derivation of unit hydrographs from isolated and complex storms
14. Derivation of unit hydrographs of different durations
15. Estimation of frequency of design flood based on risk and life of a structure
16. Frequency analysis of flood data and fitting of distributions (Gumbel, LPIII and LN)
17. Flood estimation by rational, regional rainfall-runoff and empirical methods
18. Estimation of Muskingum routing parameters k and x
19. Channel flood routing by Muskingum method
20. Channel routing by time area histogram and Clark's IUH

Practical **(15 hours)**

1. Delineation of a catchment and estimation of monthly flows and floods by different methods of a selected river
2. Video presentation and observation of meteorological instruments
3. Video presentation and discharge measurements by current meter

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Mark distribution*
1	3	4
2	8	8
3	6	8
4	3	4
5	5	8
6	8	12
7	8	10
8	4	6
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Subramanya, K. (2018), Engineering Hydrology (4th Edition). New Delhi, McGraw Hill Education (India) Pvt. Ltd. Chennai.
2. Reddy, P.J.R. (2011). A textbook of Hydrology (3rd Edition). University Science Press. Delhi.
3. Shaw, E. M., Beven, K., Chappell, N. A., Lamb, R. (2010). Hydrology in practice (4th ed.). CRC Press.

4. Linsley, R. K., Kohler, M. A., Paulhus, J. L. H. (1982). Hydrology for engineers (Latest Edition). McGraw-Hill.
5. Chow, V. T., Maidment, D. R., Mays, L. W. (1988). Applied hydrology (Latest Edition). McGraw-Hill.
6. Garg, S.K. (2010). Hydrology and Water Resources Engineering. Khanna Publishers. Delhi.
7. Sharma, K. P., Adhikari, N.R. (2004). Hydrological Estimations in Nepal. Department of Hydrology and Meteorology, Nepal.
8. Jha, P. C., Devkota, N. (2024), Irrigation and Drainage Engineering (3rd Edition). Heritage Publishers and Distributors, Kathmandu