

## ENGINEERING HYDROLOGY

### ENCE 306

Year/Part: III/I

Teaching Schedule				Examination Scheme						Total
L	T	P	Total	Theory			Practical			
				Assessment Marks	Final		Assessment Marks	Final		
					Duration (Hrs)	Marks		Duration (Hrs)	Marks	
3	2	1	6	40	3	60	25	0	0	125

**Depth Codes**

E-Explanation	VP-Visual Presentation	D-Definition	DM-Demonstration
DV-Derivation	DW-Drawing	P-Proof	I-Illustration
NUM-Numerical	SK-Sketch	S-State	PR-Practical
MP- Mini Project	EXP-Experiment	REV-Review / Recap	PS- Problem Solving
QA- Question Answer	Q- Quiz	ST- Surprise Test	MT-Mid Term Test

Unit	Topic/ Sub topic	Depth Code	Description of Depth	Actual plan			Week
				L	T	P	
<b>1</b>	<b>Introduction</b>			<b>3</b>	<b>1</b>	<b>3</b>	<b>1</b>
	1.1 Scope and application of engineering hydrology	D, E, I	Definition of hydrology, scope and application of hydrology in civil engg works	0.5			
	1.2 Hydrologic cycle and water balance equations	SK, E, NUM	Explanation of hydrological cycle with parameters; water budget/balance equations (Numerical)	1	1		
	1.3 Development of Hydro-Meteorological study and data in Nepal	E, S	Introduction to DHM, Sources and availability of hydro-meteorological data	0.5			
	1.4 Delineation of hydrological boundary and its characterization	VP, ACT, MP, PR	Process of delineation of area and channel; Estimation of catch area, channel length, slope and time of concentration for a river	1		3	
	Evaluation	QA, SK, ST					

Unit	Topic/ Sub topic	Depth Code	Description of Depth	Actual plan			Week
				L	T	P	
<b>2</b>	<b>Precipitation</b>			<b>8</b>	<b>6</b>	<b>2</b>	<b>2</b>
	2.1 Causes, forms and types of precipitation	D, E, I	Definition, causes, forms and types of precipitation	0.5			
	2.2 Rainstorm hydrology	D, E, I, NUM	Types (Symons, Tipping, Weighing, Syphon) Network and adequacy of rain-gauges (Numerical)	0.5	0.5	2	
	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	NUM, SK	Estimation of missing rainfall data; Test for consistency of record by double mass curve	0.5	1.5		

Unit	Topic/ Sub topic	Depth Code	Description of Depth	Actual plan			Week
				L	T	P	
	2.2.3 Presentation of rainfall data: Mass curve; Hyetograph; Point rainfall; Moving average annual rainfall graph	D, E, I, SK, NUM	Mass curve; Hyetograph; Point rainfall; Moving average annual rainfall graph	0.5			
	2.2.4 Cumulative distribution and probability density functions of rainfall	D, E, I, NUM	Cumulative distribution and probability density functions of rainfall	0.5			
	2.2.5 Mean rainfall over an area: Arithmetic mean, Thiessen and Isohyets	E, I, SK, NUM	Arithmetic mean, Thiessen and Isohyets methods for averaging rainfall over an area	0.5	1.5		
	2.2.6 Depth duration, depth area duration and intensity duration frequency curves	D, E, I, SK, NUM	Depth duration, depth area duration and intensity duration frequency curves and their application	0.5	1.5		
	2.2.7 Frequency of rainfall; Goodness of fit test (Chi square test)	E, I, SK, NUM	Frequency of rainfall; Goodness of fit test (Chi square test)	0.5	1		
	2.2.8 Probable maximum precipitation	D, E, I,	Definition and importance of PMP, Estimation process of PMP (Concept only)	0.5			
	2.3 Snowstorm hydrology	D, E, I	Definition of snow, Snow climatology, snow distribution and snowpack condition over an area	0.5			
	2.3.1 Snow climatology, snow distribution and snowpack condition						
	2.3.2 Snowfall measurement: Snow depth, snow stakes and snow boards	E, I, SK	Measurement of snow through snow gauge, snow stakes and snow boards. Snow surveys	0.5			
	2.3.3 Water equivalent of snow: Snow density; snow gauges and tubes	E, I, SK, NUM	Water equivalent of snow: Snow density; use of snow gauges and tubes	0.5			
	2.3.4 Remote sensing of snowpack; Ultrasonic snow depth sensor	VP, E, I	Remote sensing of snowpack; Ultrasonic snow depth sensor, use of satellite data	0.5			
	2.3.5 Snow-melting runoff process; Snowmelt-runoff modeling	VP, E, I	Snow-melting runoff process; Snowmelt-runoff modeling, SWAT, HECHMS	0.5			
	2.3.6 Changing snowpack and glaciers in a warming world	E, I	Change in snowpack and glaciers in a warming world due to climate change	0.5			
	2.3.7 Snow avalanches	VP, D, E, I	Snow avalanches and its effect in downstream	0.5			
	Evaluation	QA, Q, MT					

Unit	Topic/ Sub topic	Depth Code	Description of Depth	Actual plan			Week
				L	T	P	
<b>3</b>	<b>Abstractions from Precipitation (Hydrological Losses)</b>			<b>6</b>	<b>4</b>	<b>1</b>	<b>5</b>
	3.1 Initial losses (Interception and depression storage)	D, E, I	Initial losses due to interception and depression storage	0.5			
	3.2 Evaporation						
	3.2.1 Meteorological Parameters (Radiation, temperature, vapor pressure, humidity and wind speed)	D, E, I	Evaporation and its parameters (Radiation, temperature, vapor pressure, humidity and wind)	0.5			

Unit	Topic/ Sub topic	Depth Code	Description of Depth	Actual plan			Week
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	3.2.2 Measurement of evaporation by different types of Evaporimeters	E, I, SK	Measurement of evaporation by different types of Evaporimeters, Pan coefficients	0.5		1	
	3.2.3 Empirical evaporation equations (Meyer's and Rohwer's methods)	E, I, NUM	Empirical evaporation equations (Meyer's and Rohwer's methods)	0.5	0.5		
	3.2.4 Evaporation estimation by water-budget, energy-budget and mass transfer	E, I, NUM	Evaporation estimation by water-budget, energy-budget	0.5	0.5		
	3.3 Evapotranspiration	D, E, I, SK	Evapotranspiration: Actual evapotranspiration and Lysimeters	0.5			
	3.3.1 Actual evapotranspiration and Lysimeters						
	3.3.2 Potential evapotranspiration (Penman's equation)	D, E, I, NUM	Estimation of potential evapotranspiration by Penman's equation (Energy and mass transfer approaches)	1	1.5		
	3.4 Infiltration	D, E, I, SK	Infiltration and Percolation, Infiltration rate and capacity, Measurement of infiltration by Infiltrimeters	0.5			
	3.4.1 Measurement of infiltration by Infiltrimeters						
	3.4.2 Infiltration models (Horton, Kostiakov, Phillip and Green-Ampt)	E, I, NUM	Introduction to Infiltration models (Horton, Kostiakov, Phillip and Green-Ampt); Numerical on Horton only	0.5	1		
	3.4.3 Infiltration indices ( $\Phi$ and $W$ )	D, E, I, NUM	Estimation of infiltration indices $\Phi$ and $W$	1	0.5		
	Evaluation	QA, Q, ST					

Unit	Topic/ Sub topic	Depth Code	Description of Depth	Actual plan			Week
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<b>4</b>	<b>Surface Runoff</b>			<b>3</b>	<b>1</b>		<b>7</b>
	4.1 Factors affecting runoff from a catchment	E, I, SK	Runoff process, Direct runoff and base flow, (factors like rainfall, infiltration, catchment, channel, evapotranspiration and initial losses)	0.5			
	4.2 Runoff characteristics of rivers and streams	D, E, I, SK	Perennial, intermittent and ephemeral characteristics of rivers and streams	0.5			
	4.3 Rainfall runoff relations	E, I	Linear and exponential equations for rainfall runoff relations, Use of Khosla's equation based on monthly temperature and rainfall	0.5	0.5		
	4.4 Monthly flows by regional formulae (MIP 1990, WECS 1990, MHSP 1997)	E, I, NUM	Data needed for MIP, WECS and MHSP Estimation of monthly flows by above methods	0.5	0.5		
	4.5 Annual runoff hydrograph	E, I, SK	Annual runoff hydrograph from estimated monthly flows	0.5			
	4.6 Basics of rainfall-runoff modeling	E, I,	Empirical models, conceptual models, Continuous Model, SWAT, HECHMS. Transposition of flows from gauged basin to ungauged basin.	0.5			
	Evaluation	QA, Q, MT					

Unit	Topic/ Sub topic	Depth Code	Description of Depth	Actual plan			Week
				L	T	P	
<b>5</b>	<b>Streamflow Measurement</b>			<b>5</b>	<b>4</b>	<b>9</b>	<b>8</b>
	5.1 Stream gauging (site selection for stage and flow measurements)	D, E, I, SK	Site selection for stage and flow measurements	0.5			

Unit	Topic/ Sub topic	Depth Code	Description of Depth	Actual plan			Week
				L	T	P	
	5.2 Stage measurement (Staff and wire gauges; float gauge recorder; bubble gauge; radar)	VP, D, E, I, SK	Manual (Staff and wire gauges); Automatic (Float gauge recorder; bubble gauge; radar)	0.5			
	5.3 Velocity measurement techniques	E, I, SK, PR EXP, NUM	Velocity measurement by current meter, floats, salt dilution)	1	1	2	
	5.4 Streamflow measurement by velocity area method	E, I, SK, PR, EXP, NUM	Streamflow measurement by velocity area method in lab or in field with report	1	1	7	
	5.5 Streamflow estimation by slope area method	E, I, SK, NUM	Streamflow estimation by slope area method	0.5	0.5		
	5.6 Streamflow measurement through structures (Notches, weirs and flumes)	E, I, SK	Streamflow measurement through structures Formulae for notches, weirs and flumes	0.5			
	5.7 Rating curves: Development (Permanent and shifting control); Extrapolation and application	E, I, SK, NUM	Development of rating curves (Permanent and shifting control); Extrapolation and application	1	1.5		
	Evaluation	AQ, Q					

Unit	Topic/ Sub topic	Depth Code	Description of Depth	Actual plan			Week
				L	T	P	
<b>6</b>	<b>Hydrograph Analysis</b>			<b>8</b>	<b>6</b>		<b>10</b>
	6.1 Components of a storm hydrograph	D, E, I, SK	Definition and components of a storm hydrograph with sketch	0.5			
	6.2 Factors affecting shape of storm hydrographs	D, E, I	Factors affecting shape of storm hydrographs	0.5			
	6.3 Separation of base flow	E, I, SK	Separation of base flow by 3 methods	0.5			
	6.4 Effective rainfall hyetograph and direct runoff hydrograph	E, I, SK	Effective rainfall hyetograph and direct runoff hydrograph	0.5			
	6.5 Unit hydrographs, their uses and limitations	E, I, SK	Definition of Unit hydrographs, their uses and limitations	0.5			
	6.6 Derivation of unit hydrographs from isolated and complex storms	E, I, SK, NUM	Derivation of unit hydrographs from isolated and complex storms	2	3		
	6.7 Derivation of unit hydrographs of different durations	E, I, SK, NUM	Derivation of unit hydrographs of different durations (Method of superposition and the S-curve)	2.5	3		
	6.8 Synthetic unit hydrograph (Snyder's method)	E, I, SK	Synthetic unit hydrograph (Snyder's method)	1			
	Evaluation	QA, Q					

Unit	Topic/ Sub topic	Depth Code	Description of Depth	Actual plan			Week
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<b>7</b>	<b>Flood Hydrology</b>			<b>8</b>	<b>6</b>		<b>12</b>
	7.1 Design flood and its frequency	D, E, I	Definition of Design flood and its frequency	0.5			
	7.2 Relation of flood frequency with risk and lifespan of structure	D, E, I, NUM	Estimation of flood frequency with risk and lifespan of structure	0.5	0.5		

Unit	Topic/ Sub topic	Depth Code	Description of Depth	Actual plan			Week
				L	T	P	
	7.3 Design floods in gauged basins by frequency analysis 7.3.1 Plotting positions and probability distributions for flood prediction	E, I, SK, NUM	Design floods in gauged basins by flood frequency analysis. Plotting positions and probability distributions for flood prediction	1	0.5		
	7.3.2 Flood statistics and frequency factors	E, I, NUM	Flood statistics and frequency factors	0.5			
	7.3.3 Gumbel extreme value Type I distribution	E, I, SK, NUM	Gumbel extreme value Type I distribution. Frequency factor, Confidence limit	0.5	1		
	7.3.4 Log Pearson Type III distribution	E, I, NUM	Log Pearson Type III distribution	0.5	0.5		
	7.3.5 Log Normal distribution	E, I, SK, NUM	Log Normal distribution	0.5	0.5		
	7.3.6 Goodness of fit tests	E, I, NUM	Goodness of fit tests	0.5	0.5		
	7.4 Design floods in ungauged basins 7.4.1 Rational method using Mononobe's equation for intensity	E, I, SK, NUM	Design floods in ungauged basins Rational method using Mononobe's equation for intensity	0.5	0.5		
	7.4.2 Rainfall-Runoff methods (Snyder, BD Richard, PCJ models)	E, I, SK, NUM	Rainfall-Runoff methods (Snyder, BD Richard, PCJ models)	0.5	1		
	7.4.3 Regional empirical methods (Dickens, WECS, MHSP, DHM Methods)	E, I, SK, NUM	Regional empirical methods (Dickens, WECS, MHSP, DHM Methods)	0.5	1		
	7.5 Flash floods 7.5.1 Intense rainfall (Cloud outburst; stationary monsoon troughs; monsoon depressions)	E, I, VP	Flash floods. Intense rainfall (Cloud outburst; stationary monsoon troughs; monsoon depressions)	0.5			
	7.5.2 Geo-environmental (Glacial lake and landslide dammed outburst floods)	E, I, VP	Geo-environmental (Glacial Lake and landslide dammed outburst floods)	0.5			
	7.5.3 Impact of climate change on flash floods	E, I, VP	Impact of climate change on flash floods	0.5			
	7.6 Basics of flood modeling	E, I, SK, PR	Basics of flood modeling, Softwares	0.5			
	Evaluation	QA, Q					

Unit	Topic/ Sub topic	Depth Code	Description of Depth	Actual plan			Week
				L	T	P	
<b>8</b>	<b>Flood Routing</b>			<b>4</b>	<b>2</b>		<b>15</b>
	8.1 Concept of reservoir and channel routing; basic equations	D, E, I	Concept of reservoir and channel routing; basic equations	0.5			
	8.2 Hydrologic channel routing (Prism and wedge storage)	D, E, I	Hydrologic channel routing (Prism and wedge storage)	0.5			
	8.3 Muskingum equation and estimation of parameters (K and x)	E, I, SK, NUM	Muskingum equation and estimation of parameters (K and x)	1	1		
	8.4 Muskingum method of channel routing (Linear reservoir)	E, I, SK, NUM	Muskingum method of channel routing (Linear reservoir)	1	0.5		
	8.5 Clark's method for IUH (Time area histogram)	E, I, SK, NUM	Clark's method for IUH (Time area histogram)	1	0.5		
	Evaluation	QA, Q					

**References:** (Primarily based on the syllabus, and relevant chapters may be consulted as needed)

1. Subramanya, K. (2018), *Engineering Hydrology*. Fourth edition (All chapters except 1.3; 2.3; 4.4; 7.4 and 7.5)
2. SK Garg (2005). *Hydrology and Water Resources Engineering*. (Ch. 2.3; 5.3; 5.4; 5.5 and 5.6)
3. Jha, P. C., Devkota, N. (2024), *Irrigation and Drainage Engineering*. 3<sup>rd</sup> Edition (Ch. 1.3; 4.4, 7.4 and 7.5)

**Model Question**

**ENGINEERING HYDROLOGY [Year/Part: III/I]**

**ENCE 306 (60 to 70 Numerical and 30 to 40 Theory)**

**Full Marks: 60**

**Pass Marks: 24**

**Time: 3 Hours**

QN	Question	Marks	Unit																			
1	List the major works in which hydrological studies are required.	2	1																			
2a	Describe the different methods of recording of rainfall with sketch.	3	2																			
2b	The hyetograph of a 6-hour storm is constructed with varying time intervals: at 20 minutes' interval for the first one hour, at 40 minutes' interval for the next 2 hours and at one-hour interval for the last 3 hours. The successive ordinate of the hyetograph in mm/hr are 66, 75, 54, 48, 69, 51, 38, 47 and 25. Determine the total rainfall depth produced by the storm.	5																				
3a	Distinguish between actual and potential evapotranspiration.	3	3																			
3b	For a small catchment, the infiltration rate at the beginning of rain was observed to be 90 mm/hr and decreased exponentially to a constant rate of 8 mm/hr after 2.5 hr. The total infiltration during 2.5 hr was 50 mm. Develop the Horton's equation for the infiltration rate at any time $t < 2.5$ hr.	5																				
4a	Briefly describe factors affecting runoff from a river basin.	3	4																			
4b	What type of data are required for estimation of monthly flows by WECS and MIP methods?	3																				
5a	Explain commonly used methods of measurement of river stage with sketch.	3	5																			
5b	Determine the stage corresponding to zero discharge from the following data of a rating curve.	6																				
	<table border="1"> <tbody> <tr> <td>Stage(m)</td> <td>20.80</td> <td>21.42</td> <td>21.95</td> <td>22.37</td> <td>23.00</td> <td>23.52</td> <td>24.00</td> </tr> <tr> <td>Discharge(m<sup>3</sup>/s)</td> <td>100</td> <td>200</td> <td>300</td> <td>400</td> <td>600</td> <td>800</td> <td>1000</td> </tr> </tbody> </table>	Stage(m)		20.80	21.42	21.95	22.37	23.00	23.52	24.00	Discharge(m <sup>3</sup> /s)	100	200	300	400	600	800	1000				
Stage(m)	20.80	21.42	21.95	22.37	23.00	23.52	24.00															
Discharge(m <sup>3</sup> /s)	100	200	300	400	600	800	1000															
6a	Sketch a rainstorm hydrograph with brief description of all components.	4	6																			
6b	The ordinates of the 2-h UH of a basin at 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20 and 22 hours are 0, 25, 100, 160, 190, 170, 110, 70, 30, 20, 6 and 0 m <sup>3</sup> /s respectively. Determine the ordinates of the 4-h UH of the basin using S-curve method. Also produce 4-h flood hydrograph with a base flow of 4 m <sup>3</sup> /s.	8																				
7a	Explain the Rational method of computing the peak discharge of a small basin.	3	7																			
7b	A bridge has an expected life of 25 years and is designed for a flood of 100 years. What is the risk of this hydrologic design? If a 10% risk is acceptable, what return period will have to be adopted?	4																				
8a	Distinguish between hydraulic and hydrologic method of flood routing.	2	8																			
8b	A basin having 128 km <sup>2</sup> of drainage area has 22 hours of concentration time and 14 hours of storage constant. Determine the IUH for this basin if inter-isochrones area distribution is as below:	6																				
	<table border="1"> <tbody> <tr> <td>Travel time (hr)</td> <td>0-3</td> <td>3-6</td> <td>6-9</td> <td>9-12</td> <td>12-15</td> <td>15-18</td> <td>18-21</td> <td>21-24</td> <td>24-27</td> </tr> <tr> <td>Area(km<sup>2</sup>)</td> <td>2</td> <td>7</td> <td>17</td> <td>25</td> <td>31</td> <td>23</td> <td>14</td> <td>6</td> <td>3</td> </tr> </tbody> </table>	Travel time (hr)		0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24	24-27	Area(km <sup>2</sup> )	2	7	17	25	31	23	14	6	3
Travel time (hr)	0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24	24-27													
Area(km <sup>2</sup> )	2	7	17	25	31	23	14	6	3													

*Note: Number of questions and distribution of marks are indicative only.*