HYDRAULICS
ENCE 251

Lecture : 4 | **Year : II**
Tutorial : 2 | **Part : I**
Practical : 2/2

Course Objectives:

The objective of this course is to provide knowledge of hydraulics to impart the concept of water resources engineering and their application in the field of civil engineering. It equips students the skills to analyze and solve fluid flow problems in closed conduits and open channels. It also aims to teach practical applications through laboratory experiments and software tools.

1 Pipe Flow Regimes (8 hours)

1.1 Concept, scope and importance of pipe flow
1.2 Reynolds experiment (Laminar, transition and turbulent flows)
1.3 Steady laminar flow in circular pipes (Shear stress, velocity distribution and head loss - Hagen Poiseuille law)
1.4 Examples and characteristics of turbulent flow
1.5 Shear stress in turbulent flow (Boussinesq's, Reynold's and Prandtl's mixing length theories)
1.6 Hydrodynamically smooth and rough boundaries; Velocity distribution for turbulent flow in pipes; Nikuradse's experiments
1.7 Darcy-Weisbach equation, friction factor for turbulent flow in smooth and rough pipes; Colebrook white equation, Moody chart, introduction to Hazen-Williams equation

2 Pipe Flow Problems (10 hours)

2.1 Minor head losses in pipes (Losses due to sudden enlargement, sudden contraction, entry, exit, obstruction, gradual contraction or enlargement, bends and fittings)
2.2 Hydraulic gradient line and total energy line
2.3 Pipes in series and parallel
2.4 Siphons (Working principle and applications)
2.5 Three reservoir problems
2.6 Pipe network problems (Hardy-Cross method)

3 Unsteady Flow in Pipes (6 hours)

3.1 Concept and equations of unsteady flow
3.2 Water hammer phenomenon and effects

3.3 Velocity and magnitude of pressure waves, equation for water hammer pressure (Gradual and rapid valve closures)
3.4 Pressure variation due to sudden closure of valve (With and without head loss)

4 Uniform Flow in Open Channels (8 hours)

4.1 Classification of open channel and geometric properties
4.2 Conditions for uniform flow (Expression for shear stress on the channel boundary)
4.3 Flow resistance equations (Chezy, Manning and Darcy-Weisbach equations and their relationships; Bazin and Kutter equations)
4.4 Manning's roughness coefficient (Determination and factors affecting roughness)
4.5 Velocity distribution and profiles (Velocity distribution in rectangular, triangular, trapezoidal, and circular channel sections; velocity distribution coefficients)
4.6 Best hydraulic channel sections (Dimensions for rectangular, triangular, trapezoidal and circular sections)
4.7 Uniform flow computation (Conveyance, section factor, normal depth)

5 Energy and Momentum Principles in Open Channel Flow (12 hours)

5.1 Introduction to non-uniform flow in open channel
5.2 Energy principle (Specific energy, specific energy curve, alternate depths, and criteria for critical flow)
5.3 Critical depth computations in prismatic channel sections (Rectangular, triangular, circular and trapezoidal sections)
5.4 Depth-discharge relationship
5.5 Application of energy principle (Channel with hump; transition with a change in width; chocking; venturi flume; broad crested weir)
5.6 Momentum principle (Specific force; specific force curve; initial and sequent depths; conjugate depths; criteria for critical flow)
5.7 Application of momentum principle (Stilling basin; force on sluice gates; force on baffle blocks in stilling basin)

6 Rapidly Varied Flow in Open Channels (6 hours)

6.1 Characteristics of rapidly varied flow
6.2 Hydraulic jump (Analysis of hydraulic jump with assumptions)
6.3 Hydraulic jump in rectangular channel: Relationship between hydraulic jump variables (Conjugate depth, height of jump, efficiency of jump and length of the jump); energy loss in jump
6.4 Classification of hydraulic jump based on tail water level and Froude number

7 Gradually Varied Flow in Open Channels (10 hours)

7.1 Characteristics of gradually varied flow

7.2 Analysis of gradually varied flow (Basic assumptions for analysis, dynamic equation, dynamic equation in wide rectangular channel and control section)

7.3 Channel bottom slope: Relation between water surface and channel bottom slopes; bottom slope characteristics (Mild, critical, steep, horizontal and adverse slopes)

7.4 Water surface profiles (Classification and characteristics of water surface profiles; practical examples of water surface profiles)

7.5 Computation of gradually varied flow in prismatic channels: Direct integration (Bresse method), direct step and standard step methods

7.6 Computation of location of hydraulic jump under different flow conditions

Tutorial (30 hours)

1. Calculation of the Reynolds number and classify the flow regime (Laminar, transition, or turbulent) in a given pipe
2. Determination of the velocity distribution, shear stress, and head loss for steady laminar flow in circular pipes using the Hagen-Poiseuille equation
3. Computation of the head loss for turbulent flow in pipes using the Darcy-Weisbach equation and appropriate friction factors
4. Use the Colebrook-White equation and Moody chart to find the friction factor for turbulent flow in smooth and rough pipes
5. Calculation of the head loss due to a sudden contraction, enlargement, bends, fittings and, other minor losses in a pipe system
6. Solution for the total head loss in a system where pipes are arranged in series with varying diameters and lengths
7. Calculation of the flow distribution and head loss for pipes arranged in parallel
8. Analysis of the flow rate and pressure variations in a siphon, including head losses and practical applications
9. Calculation of the flow rates between three interconnected reservoirs using energy principles
10. Solution of flow rates and head losses in a given pipe network using Hardy-Cross method
11. Calculation of the pressure rise in a pipe due to sudden and gradual closure of a valve using the water hammer equation
12. Computation of the speed of pressure waves in pipes of different materials during transient flow conditions
13. Calculation of the flow velocity and discharge in open channels with given roughness coefficients using Manning's and Chezy's equations
14. Determination of the most efficient channel dimensions for rectangular, trapezoidal, and circular sections based on specific flow rates

15. Computation of the specific energy and critical depth in various channel shapes (Rectangular, trapezoidal, and triangular channels)
16. Solution of flow characteristics over a channel with a hump, transition with width change, through a Venturi flume and, broad-crested weir
17. Calculation of forces on sluice gates, baffle blocks, and stilling basins using the momentum principle
18. Determination of conjugate depths, energy loss, and jump efficiency for hydraulic jumps in rectangular channels
19. Calculation of the water surface profile for prismatic channels using direct integration, direct step and, standard step methods
20. Computation of the location of a hydraulic jump in an open channel under varying flow conditions

Assignment

Practical problem-solving for pipe flow and open channel flow using appropriate modeling tools.

Practical **(15 hours)**

1. Reynolds' experiment
2. Head loss in pipes
3. Determination of Manning's coefficient for different surfaces
4. Flow through open sluice gates
5. Hump and constricted flow analysis
6. Hydraulic jump analysis

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	Marks distribution*
1	8	8
2	10	10
3	6	6
4	8	8
5	12	12
6	6	6
7	10	10
Total	60	60

* There may be minor deviation in marks distribution.

References

1. Chow, V.T. (2009). Open-channel hydraulics. The Blackburn Press.
2. Chaudhry, M.H. (2014). Applied hydraulic transients (3rd edition). Springer.
3. Chaudhry, M.H. (2008). Open-channel flow (2nd edition). Springer.

4. Modi, P.N., Seth, S.M. (2022). Hydraulics and fluid mechanics including hydraulic machines (23rd edition). Standard Book House.
5. Kumar, K.L. (2021). Engineering fluid mechanics (9th edition) S. Chand Publishing.
6. Çengel, Y.A., Cimbala, J.M. (2022). Fluid mechanics: Fundamentals and applications (4th edition). McGraw-Hill Education
7. Crowe, C.T., Elger, D.F., Williams, B.C. (2021). Engineering fluid mechanics (11th edition). Wiley.
8. Larock, B.E., Jeppson, R.W., Watters, G. Z. (2014). Hydraulics of pipeline systems (2nd edition). CRC Press.
9. Sangroula, D.P., Bhattarai, P.K. (2017). A textbook of hydraulics: Fundamentals and applications (2nd edition). Green Books.