INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500043

COURSE CONTENT

HYDRAULICS AND HYDRAULIC MACHINERY LABORATORY									
IV Semester: CE									
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**			
ACEC12	**Core**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**	
		0	0	3	1.5	30	70	100	
Contact Classes:	**Total Tutorials:**	**Total Practical Classes: 45**				**Total Classes: 45**			
Prerequisite: No prerequisites required									

I. COURSE OVERVIEW:

The Hydraulics and Hydraulic Machinery Laboratory course is an indispensable supplement to theoretical knowledge. The course delves into the intricacies of fluid dynamics, offering a comprehensive study of hydraulic systems, theoretical principles and practical applications. It engages in in-depth analyses of hydraulic components, pumps, valves, and actuators, enhancing their proficiency in the design and optimization of hydraulic machinery. This course will focus on the behaviour of fluid under various conditions, providing hands-on experience in the fluid mechanics laboratory to explore principles such as flow dynamics, viscosity, and turbulence.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The fundamental knowledge of fluid properties and behavior under static and dynamic conditions of closed conduit and open channels.

II. The operating principle of various turbo machinery and analyze their performance characteristics under various operating conditions.

III. The measurement of flow rate through various internal and external fluid flow systems

III. COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1 Outline the concept of calibrating orifice and venturi meter to minimize uncertainty in the discharge coefficient.

CO 2 Analyze the basic concepts of flow through the pipes and their losses for determining fluid pressure and head.

CO 3 Measure the discharge through various notches to determine the flow of fluids in different hydraulic structures.

CO 4 Examine the flow patterns in different flow conditions for determining the velocities, pressures and acceleration in a moving liquid.

CO 5 Interpret the law of conservation of energy, Bernoulli’s theorem for estimating total energy of various geometrical cross-section of a pipe.

CO 6 Compare the performance characteristics of various turbines in different operating conditions for enhancing efficiency and output under specific applications.

IV. COURSE CONTENT

EXCERCISES ON HYDRAULICS AND HYDRAULIC MACHINERY LABORATORY

Getting Started Exercises

Introduction

The Fluid Mechanics and Hydraulic Machines Laboratory is a fundamental space within the realm of engineering education, providing students with hands-on experience and practical insights into the principles governing fluid behavior and hydraulic machinery. This laboratory is specifically designed to complement theoretical knowledge with real-world experiments, fostering a deeper understanding of fluid mechanics concepts and hydraulic system dynamics.

1. VENTURIMETER

1.1 Determine the coefficient of discharge for fluid flow at different operating conditions i.e., 1/4th, 1/2th, 3/4th, and full opening within a pipeline as shown in Fig. 1.

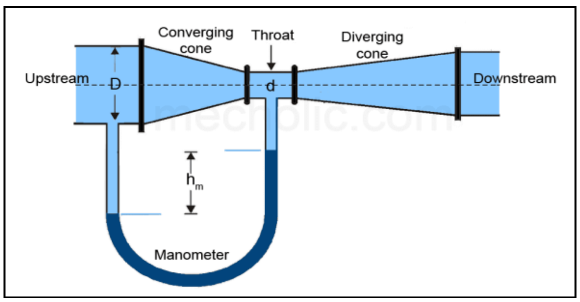

Fig:1 Venturimeter

1.2 Determine the quantification of energy loss in the venturi meter system in a pipeline.

Try:

1. How does the variation in fluid flow rates affect the accuracy of venturimeter?
2. What mechanisms explain the relationship between fluid properties and the precision of venturimeter measurements?
3. What factors contribute to the impact of pipe diameter and material on venturimeter readings?

2. ORIFICE METER

2.1 Determine the coefficient of discharge for fluid flow at different operating conditions like partially opened, half opened and fully opened within a pipeline as shown in Fig 2.

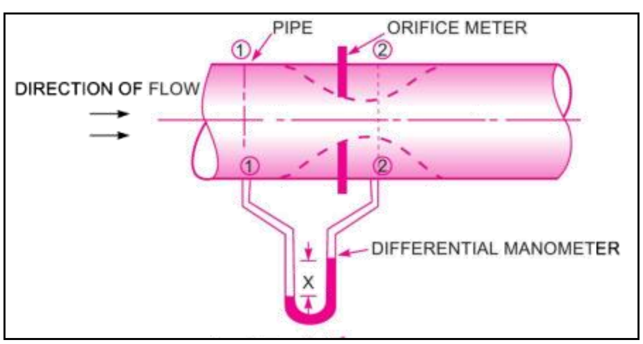

Fig:2 Orifice meter

2.2 Investigate the changing pattern of downstream pressure along the pipe subsequent to passing through the orifice.

Try:

1. How do variations in fluid flow rates influence the accuracy of orifice meters?
2. What mechanisms elucidate the relationship between fluid properties and the precision of orifice meter measurements?
3. Which factors contribute to the impact of pipe diameter and material on orifice meter readings?

3. BERNOULLI'S EQUATION FOR HORIZONTAL AND INCLINED PIPES

3.1 Determine the total head which relating to the fluid pressure, velocity, and potential energy for analyzing the fluid flow behaviors in engineering applications. The testing apparatus is illustrated in Fig.3.

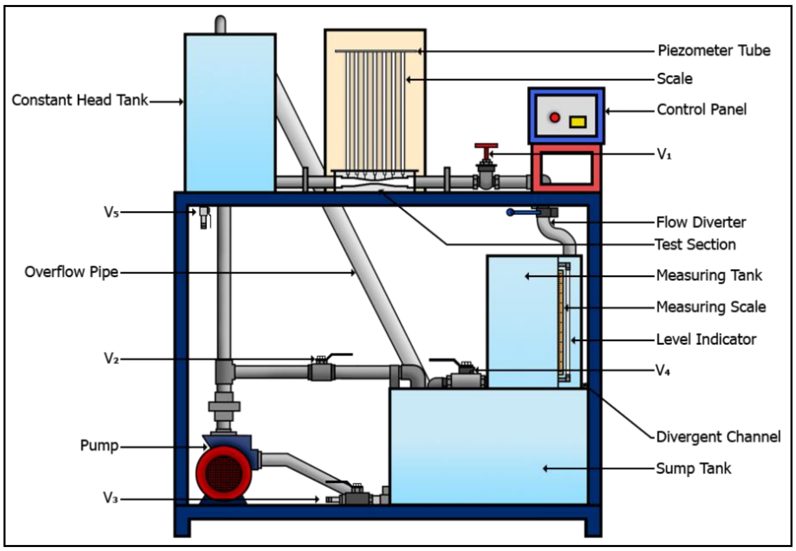

Fig. 3 Bernoulli's equation

3.2 Calculate the quantification of energy loss in Bernoulli's experiment.

Try:

1. How do variations in fluid velocity affect the application and accuracy of Bernoulli's equation?
2. What mechanisms elucidate the relationship between fluid properties and the precision of Bernoulli's equation in predicting pressure and velocity changes?
3. Which factors contribute to the impact of pipe geometry and fluid density on the application of Bernoulli's equation in practical fluid systems?

4. FRICTION FACTOR OF CIRCULAR AND NON-CIRCULAR PIPES

4.1 Determine the coefficient of Darcy's friction factor under partial, half, Three-fourths and fully opening flow conditions for circular pipeline. The testing apparatus is illustrated in Fig. 4.

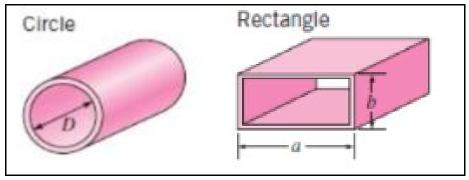

Fig.4 Circular and Rectangular (Non-Circular) pipes

4.2 Calculate the Darcy's friction factor for flow variations in a rectangular pipeline.

Try:

1. For optimizing the efficiency of pipelines, what considerations should be considered for various applications?
2. What methods are used to determine the plasticity index and shrinkage limit in diverse soil types?
3. Discuss how engineers can strategically select materials and design parameters to minimize head losses and enhance the performance of fluid conveyance in diverse piping system.

5. CONVERGENT LOSSES IN A PIPE

5.1 Determine the coefficient of discharge for different flow rates viz., 1/4th, 1/2th, 3/4th, and full opening in a pipe network. The testing apparatus for evaluating convergent losses is depicted in Fig. 5.

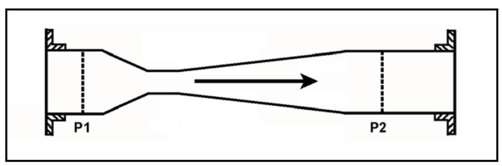

Fig.5. Convergent pipe

5.2 Investigate the changing pattern of pressure along the pipe passing through convergent throat in a pipeline.

Try:

1. What are the distinct flow characteristics in convergent flow configuration and how do these differences contribute to variations in minor losses?
2. How stable are convergent configuration under varying flow regimes, and what conditions may induce instability in each configuration?

6. DIVERGENT LOSSES IN A PIPE

6.1 Determine the coefficient of discharge for flow rates under different opening conditions like 1/4th, 1/2th, 3/4th, and full opening in a pipe line. The testing apparatus for evaluating divergent losses is illustrated in Fig.6.

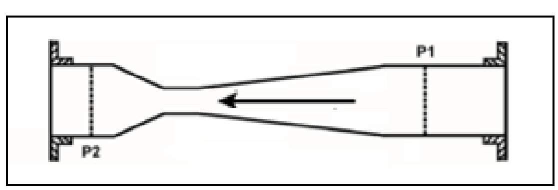

Fig.6 Divergent pipe

6.2 Investigate the changing pattern of pressure along the pipe passing through divergent throat in a pipeline.

Try:

1. What roles do fluid properties, pipe geometry, and flow conditions play in determining the magnitude of minor losses, and how can engineering decisions optimize the choice between convergent and divergent flow configurations to minimize these losses.
2. How does the pressure-velocity relationship differ in convergent and divergent sections, and what impact does it have on energy losses?

7. RECTANGULAR, TRIANGULAR AND TRAPEZIODAL NOTCH

Determine the coefficient of discharge for different operating conditions like partial opened, half opened and full opened of the pipe flow for different cross-sectional notches, i.e. Rectangular, triangular, and trapezoidal notches are shown in below Fig. 7.

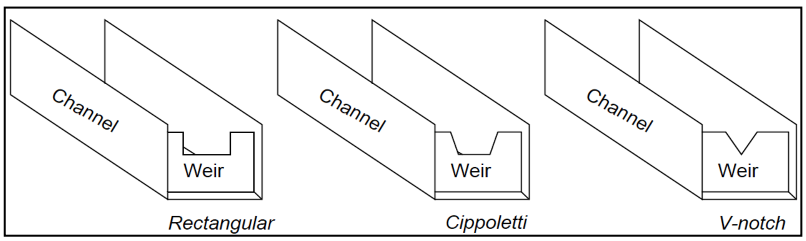

Fig. 7 Types of notches in a channel

Try:

1. How does the shape and dimensions of a notch impact its discharge coefficient for accurate flow rate measurements?
2. In what ways do notches contribute to the design and optimization of hydraulic infrastructure?
3. How can the precise measurement of flow rates through notches aid in sustainable decision-making for agricultural, industrial, and environmental applications?

8. IMPACT OF JET ON VANES (FLAT, CURVED VANES)

8.1 Determine the reaction forces produced by the change in momentum of a fluid flow when a jet of water strikes a flat plate. Stationary surfaces like flat and curved vanes as shown in Fig. 8.

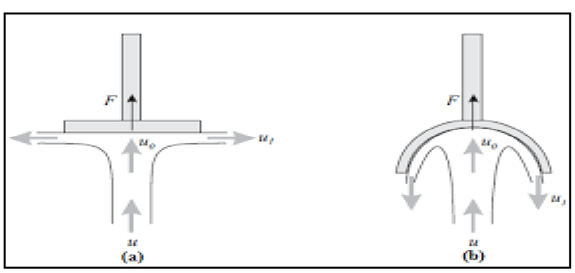

Fig. 8 Impact of Jet on vanes

8.2 Determining the reaction forces generated by the change in momentum when a jet of water strikes a curved surface.

Try:

1. How does the orientation of a flat and curved vane impact the resultant forces and deflections when subjected to a high-velocity water jet?
2. How does the design of flat vanes differ from curved vanes in terms of their response to the impact of a high-velocity jet?
3. In the context of the impact of a jet on vanes, what role do principles of impulse and reaction play?

9. PERFORMANCE OF PELTON TURBINE

9.1 Determine the kinetic energy of water at high heads into mechanical power, generating efficient and sustainable electricity in mountainous regions.

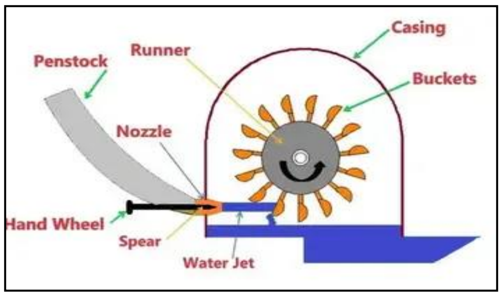

Fig. 9 Pelton wheel turbine apparatus.

9.2 Calculate the overall efficiency of Pelton turbine. The testing apparatus are shown in fig. 8.

Try:

1. How does the choice of turbine design, such as Pelton wheel impact the overall efficiency and adaptability of hydropower systems, considering varying water heads and geotechnical conditions?
2. What are the key factors influencing the comparative efficiency of different Pelton wheel designs?
3. In what ways does soil settlement due to vibratory compaction impact the stability of Pelton wheel turbine foundations, and what geotechnical considerations are crucial for their long-term operation in diverse terrains?

10. PERFROMANCE OF KAPLAN TURBINE

10.1 Efficiently convert the kinetic energy of water in low-head environments into mechanical power for different operating conditions i.e., 1/4th, 1/2th, 3/4th, and full opening contributing to sustainable energy generation.

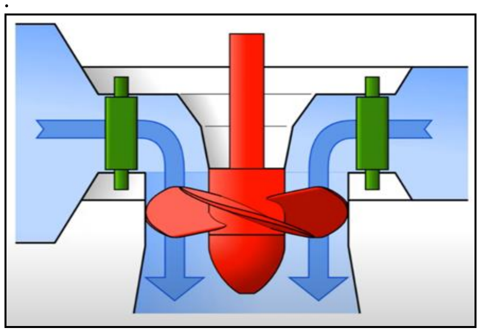

Fig. 9 Kaplan Turbine

10.2 Calculate the overall efficiency of Kaplan turbine as shown in fig. 10.

Try;

1. How does the choice of turbine design, such as Kaplan impact the overall efficiency and adaptability of hydropower systems, considering varying water heads and geotechnical conditions?
2. What insights can be derived from a comparative analysis of hub designs in Kaplan turbines, and how can engineers tailor configurations to maximize energy extraction in low-head hydropower applications?
3. In what ways does soil settlement due to vibratory compaction impact the foundations supporting Kaplan turbines, and what geotechnical measures are necessary to ensure stability and durability in low-head hydropower projects?

11. PERFORMANCE OF SINGLE STAGE CENTRIFUGAL PUMP

11.1 Analyze the operational efficiency and characteristics of a single-stage centrifugal pump under varying conditions i.e., 1/4th, 1/2th, 3/4th, and full opening of flow rate and head.

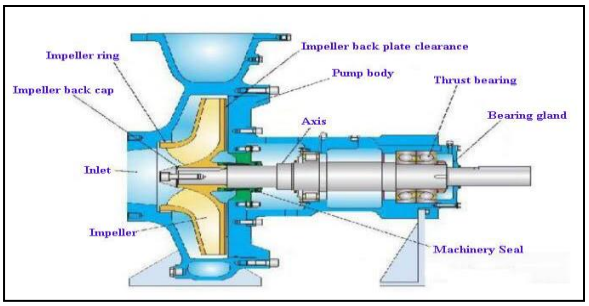

Fig.11 Single stage reciprocating pump

11.2 Calculate the overall efficiency of single stage centrifugal pump. The testing apparatus are shown in fig. 11.

Try:

1. How can its design be adapted to cater to a wide range of fluid transport applications requiring moderate pressure and flow rates?
2. In what ways does the single-stage centrifugal pump excel in converting rotational energy into kinetic energy
3. What considerations should be taken into account when selecting a single-stage centrifugal pump for applications requiring moderate pressure?

12. PERFORMANCE OF MULTISTAGE CENTRIFUGAL PUMP

12.1 Evaluate the operational efficiency and characteristics of a multistage centrifugal pump, considering different flow rates i.e., partial, half, three-fourth and full operating head conditions in a series of stages.

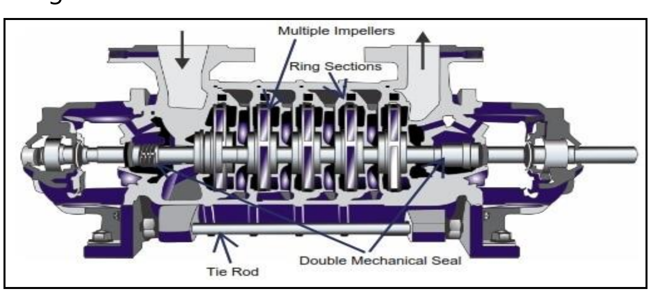

Fig. 12: Multistage centrifugal pump apparatus.

12.2 Calculate the overall efficiency of multistage centrifugal pump. The testing apparatus are shown in fig. 12.

Try:

1. How does the sequential energy impartation in a multistage centrifugal pump contribute to its ability to generate high pressure and handle substantial flow rates, and what industries benefit most from this design feature?
2. What challenges do multistage centrifugal pumps address in industrial fluid transport?
3. What specific features make it a preferred choice for fluid transport in complex scenarios that demand both high pressure and substantial flow rates?

13. PERFORMANCE ON SINGLE ACTING RECIPROCATING PUMP

13.1 Analyze the performance characteristics, efficiency, and operational parameters of a reciprocating pump operating in a single stage configuration under various flow rates like partial, half, three-fourth and full operating conditions.
acting reciprocating pump as shown in Fig.12.

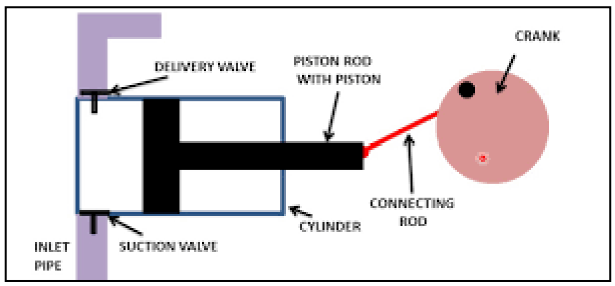

Fig 13: Single stage reciprocating pump

13.2 Calculate the overall efficiency of single stage reciprocating pump.

Try:

1. What considerations are essential for optimizing its intermittent and moderate flow performance?
2. In what ways does a single-acting reciprocating pump contribute to reliable and controlled fluid flow in applications like water supply and small-scale irrigation
3. How does its design align with providing intermittent pumping and moderate pressures for specific applications requiring controlled fluid movement.

14. FRANCIS TURBINE

14.1 Determine the energy to convert the kinetic power of water into mechanical power under varying head conditions i.e., partial, half, three-fourth and full operating, providing reliable and adaptable electricity generation.

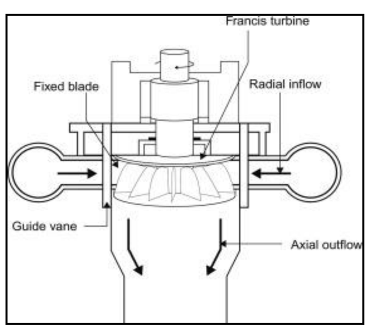

Fig 14 Francis turbine apparatus.

14.2 Calculate the overall efficiency of Francis turbine. The testing apparatus are shown in fig.

Try:

1. What comparative insights can be gained from analyzing different compounding methods for Francis turbines, and how can engineers enhance their adaptability and efficiency in medium-head hydropower installations?
2. What are the potential effects of soil settlement on structures supporting Francis turbines, and how can geotechnical assessments ensure the stability and longevity of these turbines in various environments?
3. How does the choice of turbine design, such as Francis impact the overall efficiency and adaptability of hydropower systems, considering varying water heads and geotechnical conditions?

V. TEXT BOOKS:

1. C.S. P.Ojha, R. Berndtsson and P. N. Chandarmouli, ‘Fluid Mechanics and Machinery’, Oxford University Press, 2010.
2. P M Modi and S M Seth, ‘Hydraulics and Fluid Mechanics’, Standard Book House.
3. K. Subramanya, ‘Theory and Applications of Fluid Mechanics’, Tata McGraw Hill.
4. R.L. Daugherty, J.B. Franzini and E.J. Finnemore, ‘Fluid Mechanics with Engineering Applications’, International, Student Edition, McGraw Hill.

VI. REFERENCE BOOKS:

1. http://site.iugaza.edu.ps/mymousa/files/Fluid-Mechanics-and-Hydraulics-Lab-Manual-2015-.pdf
2. http://www.public.asu.edu/~lwmays/classes/cee341/manual.pdf
3. https://issuu.com/loisburchette4023/docs/fluid-mechanics-lab-manual-for-mech

VII. ELECTRONICS RESOURCES:

1. http://nptel.ac.in/courses/105102012/
2. http://nptel.ac.in/courses/105104030/

VIII. MATERIALS ONLINE:

1. Course Description
2. Laboratory manual