K.S.R COLLEGE OF ENGINEERING (Autonomous)

Vision of the Institution

- We envision to achieve status as an excellent educational institution in the global knowledge hub, making self-learners, experts, ethical and responsible engineers, technologists, scientists, managers, administrators, and entrepreneurs who will significantly contribute to research and environment friendly sustainable growth of the nation and the world.

Mission of the Institution

- To inculcate in the students self-learning abilities that enable them to become competitive and considerate engineers, technologists, scientists, managers, administrators, and entrepreneurs by diligently imparting the best of education, nurturing environmental and social needs.
- To foster and maintain a mutually beneficial partnership with global industries and Institutions through knowledge sharing, collaborative research and innovation.

DEPARTMENT OF AUTOMOBILE ENGINEERING

Vision of the Department

- To build long tradition of excellence to be the leading Automobile Engineering program in partnership with our students, alumni, industry and government. The department shall provide the students with educational experiences that will enable them to become leaders in their profession and society. The department shall also maintain and develop world-class research programs that complement our educational mission, address the evolving needs of industry and society, and contribute to economic and social development in the State of Tamil Nadu, across the nation, and around the world.

Mission of the Department

- To serve students, industry and society by fulfilling the missions of discovery, learning, and engagement through the creation and dissemination.
- To apply Engineering methods, knowledge, and professional standards relevant to the practice of Automobile Engineering in the many aspects of modern life where it plays a crucial role.

Programme Educational Objectives (PEOs) of B.E. - Automobile Engineering

- Graduates are knowledgeable in the areas of Automobile industries and successful in their professional career.
- Graduates Continue significant work in their chosen career, and demonstrate social and ethical responsibility.
- Graduates perform both independently and as a member of a team in project management.

COURSE FACULTY **H.O.D** **PRINCIPAL**

K.S.R COLLEGE OF ENGINEERING (Autonomous)
Department of Automobile Engineering

Subject Name: FLUID MECHANICS AND HYDRAULIC MACHINES
Subject Code: 20AU312 **Year/Semester: II/III**

Course Outcomes: On completion of this course, the student will be able to

CO1: Apply mathematical knowledge to predict the properties and flow characteristics of a fluid.
CO2: Analyze the boundary layer concepts and major and minor losses associated with pipe flow.
CO3: Interpret the results of dimensional and model analysis.
CO4: Illustrate the operation and performance of various hydraulic turbines.
CO5: Evaluate the performance and operation of hydraulic pumps.

B. Program Outcomes (POs)
Engineering Graduates will be able to:

PO1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

PO2.**Problem analysis:** Identify, formulate review research literature, and analyze complex engineering problems reaching substantiated conclusion using first principles of mathematics, natural sciences, and engineering sciences.

PO3. **Design /development of solutions:** Design solutions for complex engineering problems and design system components or process that meet the specified needs with appropriate consideration for the public health and safety, and the cultural. Societal, and environmental consideration.

PO4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including Design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5.**Modern tool usage:** Create, select and apply appropriate techniques, resource, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6.**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7.**Environment and sustainability:** Understand the impact of the professional engineering solutions in social and environmental contexts, and demonstrate the knowledge of and need for sustainable development.

PO8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibility and norms engineering practice.

PO9 .**Individual and team work**: Function effectively as an individual, and as member or leader diverse teams, and in Multidisciplinary settings.

PO10.**Communication:** Communicate effectively on complex engineering activities with the engineering community, and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11.**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12**. Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-Long learning in the broadcast context of technological change.

B. Program Specific Outcomes (PSOs)

PSO1**. Research culture**: Apply the concepts of electro-mechanical systems, analyse the various automobile components and use design tools specific to automobile industry.

PSO2**. Core values**: Diagnose the automotive system failures and repair / replace the components / systems..

COURSE FACULTY **H.O.D** **PRINCIPAL**

SEMESTER – III

20AU312	FLUID MECHANICS AND HYDRAULIC MACHINES	L	T	P	C
		3	0	0	3

Prerequisite: -

Course Outcomes : On successful completion of this course, the student will be able to		***Cognitive Level***
CO1:	*Apply mathematical knowledge to predict the properties and flow characteristics of a fluid.*	*Apply*
CO2:	*Analyze the boundary layer concepts and major and minor losses associated with pipe flow.*	*Apply*
CO3:	*Interpret the results of dimensional and model analysis.*	*Understand*
CO4:	*Illustrate the operation and performance of various hydraulic turbines.*	*Understand*
CO5:	*Evaluate the performance and operation of hydraulic pumps.*	*Understand*

UNIT – I FLUID PROPERTIES AND FLOW CHARACTERISTICS [09]

Classification of fluids – Fluid properties – Pressure Measurements – Flow characteristics – Concept of control volume and system – Continuity equation, energy equation and momentum equation – Applications.

UNIT – II FLOW THROUGH PIPES [09]

Laminar flow through the circular pipes – Darcy Weisbach equation – Friction factor – Moody diagram – Minor losses – Hydraulic and energy gradient – Flow through pipes in series and parallel – Boundary layer concepts – Types of boundary layer thickness.

UNIT – III DIMENSIONAL AND MODEL ANALYSIS [09]

Dimensional analysis: Dimensions – Dimensional homogeneity – Rayleigh's method and Buckingham Pi theorem – Dimensionless parameters – Similitude and model studies – Distorted and undistorted models.

UNIT– IV HYDRAULIC TURBINES [09]

Impact of jets – Velocity triangles – Theory of roto-dynamics machines – Classification of turbines – Pelton wheel, Francis turbine and Kaplan turbine – Working principles – Work done by water on the runner – Efficiencies – Draft tube – Specific speed – Performance curves for turbines – Governing of turbines.

UNIT – V HYDRAULIC PUMPS [09]

Classification of pumps – Centrifugal pumps – Working principle – Heads and efficiencies – Velocity triangles – Work done by the impeller – Performance curves – Reciprocating pump – Working principle – Indicator diagrams – Work saved by air vessels. Rotary pumps – Classification. Working principle.

Total = 45 Periods

Text Books :

1 Bansal R.K, A Textbook of Fluid Mechanics and Hydraulic Machines, Laxmi Publications (P) Ltd., New Delhi, Tenth Edition, 2018.

2 Rajput R.K, A Textbook of Fluid Mechanics and Hydraulic Machines, S.Chand & Company Ltd., New Delhi, Sixth Edition, 2016.

Reference Books :

1 Modi.P.N. and Seth.S.M, Hydraulics and Fluid Mechanics, Standard Book House, New Delhi, Twenty-first Edition, 2017.

2 Kumar. K.L., Engineering Fluid Mechanics, Eurasia Publishing House (P) Ltd., New Delhi, Seventh Edition, 2016.

3 V.L. Streeter and Wylie E.B., Fluid Mechanics, Tata McGraw-Hill Education, New Delhi, Ninth Edition, 2017.

4 Rathakrishnan. E, Fluid Mechanics: An Introduction, Prentice Hall India Learning Private Limited, New Delhi, Third Edition, 2007.

K.S.R.COLLEGE OF ENGINEERING (Autonomous), TIRUCHENGODE-637 215

DEPARTMENT OF AUTOMOBILE ENGINEERING

Year / Sem : **II / III**
Subject code & Name : **20AU312- FLUID MECHANICS AND HYDRAULIC MACHINES**
Handled By : **Dr. S.NEELAMEGAN**

COURSE / LESSON PLAN SCHEDULE

A) TEXT BOOK:

T1. Bansal R.K, A Textbook of Fluid Mechanics and Hydraulic Machines, Laxmi Publications (P) Ltd., New Delhi, Tenth Edition, 2018.
T2. Rajput R.K, A Textbook of Fluid Mechanics and Hydraulic Machines, S.Chand & Company Ltd., New Delhi, Sixth Edition, 2016.

B) REFERENCE BOOK:

R1. Modi.P.N. and Seth.S.M, Hydraulics and Fluid Mechanics, Standard Book House, New Delhi, Twenty-first Edition, 2017.
R2. Kumar. K.L., Engineering Fluid Mechanics, Eurasia Publishing House (P) Ltd., New Delhi, Seventh Edition, 2016.
R3. V.L. Streeter and Wylie E.B., Fluid Mechanics, Tata McGraw-Hill Education, New Delhi, Ninth Edition, 2017.
R4. Rathakrishnan. E, Fluid Mechanics: An Introduction, Prentice Hall India Learning Private Limited, New Delhi, Third Edition, 2007

C) LEGEND:

L - Lecture
T - Tutorial
OHP - Over Head Projector
T_X - Reference
PPT - Power Point
BB - Black Board
P - Pages
Ex - Extra

Sl. No	Lecture Hour	Topics to be covered	Teaching Aid Required	Book No. /Page No
UNIT I FLUID PROPERTIES AND FLOW CHARACTERISTICS				
1.	**L1**	Classification of fluids -Fluids Properties – Mass density, specific gravity, specific weight, Specific volume	BB	T1-P1 to 2R4- P 1.6 to 1.9
2.	**L2**	Viscosity, compressibility, vapour pressure and Capillarity and surface tension	BB	T1-P3 to 5 T1-P21 to 29 T1-P29 T1-P34 to 35
3.	**L3**	Problems solved in properties of fluids, Capillary & Surface tension, Pressure Measurements	BB	T1-P3 to 22 T1-P 24 to 29
4.	**L4**	Flow characteristics: concepts of control volume	BB	R3- P 88 to 91
5.	**L5**	continuity equation- Application	BB	R3 – P 92

6.	**L6**	Energy equation	BB	R3 – P92 to 93
7.	**L7**	Energy equation	BB	R3 – P92 to 93
8.	**L8**	Momemtum equation	BB	T1 – P 285 to 286
9.	**L9**	Problem solved in energy equation and Momentum equation	BB	T1-P 285 to 286 R3 – P92 to 93
		UNIT II FLOW THROUGH PIPES		
10.	**L10**	Laminar flow though the circular pipes	BB	R3- P 190 to 194
11.	**L11**	Hydraulic and energy gradient	BB	T1-P 486
12.	**L12**	Darcy – Weisbach equation.	BB	T1-P 429- 431
13.	**L13**	Friction factor and Moody diagram.	BB	T1-P 429- 431, R3-P237,238
14.	**L14**	Minor losses	BB	R3-P 466 to 486
15.	**T15**	Flow though pipes in series.	BB	T1-P 497 to 501
16.	**L16**	Flow though pipes in parallel.	BB	T1-P 503 to 519
17.	**L17**	Boundary layer concepts	BB	T1-P 606 to 646
18.	**L18**	Types of boundary layer thickness	BB	T1-P 606 to 646
		UNIT III DIMENSIONAL AND MODEL ANALYSIS		
19.	**L19**	Dimension and units	BB	T1-P 554 to 560
20.	**L20**	Dimensional Homogeneity, Methods of dimensional analysis,	BB	T1-P561 - 562
21.	**L21**	Rayleigh's method & Buckingham's Π theorem	BB	T1-P 560 - 574
22.	**L22**	Problems solved in Buckingham's Π theorem	BB	T1-P 560 - 574
23.	**L23**	Dimensionless Parameters.	BB	T1-P 581 - 583
24.	**L24**	Applications of dimensionless parameters	BB	R4-P 3.17 to 3.28
25.	**L25**	Similitude, types of similitude.	BB	T1-P 579 - 580
26.	**L26**	Model studies	BB	T1-P 583 - 597

27.	**L27**	Distorted and undistorted models	BB	T1-P 583 - 597
UNIT IV HYDRAULIC TURBINES				
28.	**L28**	Impact of jets, Theory of roto-dynamics machines	BB	R3-P378 to 384 T1-P 805 - 811
29.	**L29**	Velocity components at entry and exit of the rotor, velocity triangles	BB	R3-P378 to 380
30.	**L30**	Classification of Turbines, Head and efficiencies – Velocity triangles	BB	T1 853 - 857
31.	**L31**	Axial, radial and mixed flow turbines. Pelton Wheel – working principles, work done by water on runner	BB	T1-P 857 - 877
32.	**L32**	Francis turbine - working principles, work done by water on runner	BB	T1-P 895 - 903
33.	**L33**	Kaplan turbine - working principles, work done by water on runner	BB	T1-P 904 - 910
34.	**L34**	Draft tube	BB	T1-P 915 - 919
35.	**L35**	Specific speed, unit quantities	BB	T1-P 920 - 932
36.	**L36**	Performance curves for Turbines, Governing of turbines	BB	T1-P 933 - 935
UNIT V HYDRAULIC PUMPS				
37.	**L37**	Classification of pumps -Centrifugal pumps, working principle	BB	T1-P 945 - 947
38.	**L38**	Heads and efficiencies, Velocity triangles	BB	T1-P 947 - 948
39.	**L39**	Work done by the impeller	BB	T1-P 947 - 948
40.	**L40**	Performance curves of centrifugal pumps	BB	T1-P 978 - 980
41.	**L41**	Reciprocating pumps – working principle, classification	BB	T1-P 993 to 998
42.	**L42**	Indicator diagrams, Work saved by air vessels	BB	T1-P 1003 to 1005 T1-1021 - 1028
43.	**L43**	Problems solved in Reciprocating pumps	BB	T1-P 995 to 1013
44.	**L44**	Rotary pumps. Classification	BB	R4-P 5.64 to 5.68
45.	**L45**	Working and performance curves	BB	R4-P 5.64 to 5.68

PREPARED BY **H.O.D./AE**
(Dr. S.NEELAMEGAN)

KSR COLLEGE OF ENGINEERING
DEPARTMENT OF AUTOMOBILE ENGINEERING
16AU315 – FLUID MECHANICS AND HYDRAULIC MACHINERY

UNIT – I

FLUID PROPERTIES AND FLOW CHARACTERISTICS

PART – A

1. **What is meant by continuum? (CO1) (Rememdering) (AU Nov '08)**
   A continuous and homogeneous medium is called continuum. From the continuum view point, the overall properties and behavior of fluids can be studied without regard its atomic and molecular structure.
2. **Define: Mass density and Weight density of fluids. (CO1) (Rememdering) (AU Nov '07)**
   Mass Density (ρ) of the fluid is defined as the ratio of the mass of the fluid to its volume. Unit- Kg/m^3.
   Weight Density (w) of the fluid is the ratio between the weight of the fluid to its volume.
3. **State the continuity equation for case of general 3-D flow? (CO1) (Understanding) (AU Nov'07, Dec'09)**
   $$\frac{\delta}{\delta x}(\rho u) + \frac{\delta}{\delta y}(\rho v) + \frac{\delta}{\delta z}(\rho w) = 0$$
4. **Define: kinematic and dynamic viscosity? (CO1) (Rememdering) (AU May '09, Nov '11)**
   Dynamic viscosity (μ) is defined as shear stress on a fluid element layer is directly proportional to the rate of shear strain.
   Unit – Ns/m^2, Dimension – $ML^{-1}T^{-1}$
   Kinematic Viscosity (υ) is defined as the ratio between the dynamic viscosity and density of fluid.
   Unit - m^2/s Dimension – $L^{-2}T^{-1}$
5. **State Newton's law of viscosity? And write the relationship between shear stress and velocity gradient. (CO1) (Understanding) (AU May '07, Nov '05, Dec'09)**
   It states that the shear stress on a fluid element layer is directly proportional to the rate of shear strain.
   $$\tau = \mu \frac{du}{dy}$$
6. **What is meant by capillarity? (CO1) (Rememdering) (AU Dec'05, Nov '06)**
   It is defined as a phenomenon of rise or fall of a liquid surface in a small tube relative to the adjacent general level of liquid when the tube is held vertically in the liquid.
   The rise of liquid surface is known as capillary rise.
   The fall of liquid surface is known as capillary depression.
7. **Define compressibility of a fluid? (CO1) (Rememdering) (AU May'05, Dec'09)**
   Compressibility is the reciprocal of the bulk modulus of elasticity (K). The bulk modulus of elasticity (K) is defined as the ratio of compressive stress to volumetric strain.
8. **What is viscosity? What is the effect of temperature on viscosity of water and that of air? (AU Nov '05, Nov '04) (CO1) (Analyzing)**
   Viscosity is defined as the property of a fluid which offers resistance to the movement of one layer of fluid over another layer adjacent layer of the fluid.
   The viscosity of liquids decreases with the increase of temperature while the viscosity of gases increases with the increase of temperature.
9. **Distinguish between ideal fluid and real fluid? (CO1) (Analyzing)**
   Ideal fluid
   1. It is incompressible
   2. It is having no viscosity.

3. It is only an imaginary fluid.

Real fluid
1. It is compressible.
2. They are viscous in nature.
3. Shear stress always exists in such fluids.

10. Calculate the capillary effect in a glass tube of 3.5 mm diameter immersed in mercury having surface tension 0.51N/m. (CO1) (Evaluating)

11. Define surface tension (σ). Write the units and dimensions for surface tension of a fluid? (CO1) (Rememdering) (AU May'11)

It is defined as the tensile force acting on the surface of a liquid in contact with a gas or on the surface between two immiscible liquids such that the contact surface behaves like a membrance under tension.

Unit – N/m. Dimension – MT^{-1}

12. What are the basic assumptions made in deriving Bernoulli's theorem? (CO1) (Analyzing) (AU May'08, Dec'09)
1. The liquid is ideal and incompressible.
2. The flow is steady and continuous.
3. The only forces acting on the fluids are the gravity force and the pressure force.

13. Distinguish between Newtonian fluid and Non-Newtonian fluid? (CO1) (Analyzing) (AU Nov '09)

Newtonian fluid

A real fluid, in which the shear stress is directly proportional to the rate of shear strain, is known as a Newtonian fluid.

Ex: Water, Kerosene.

Non- Newtonian fluid

A real fluid, in which the shear stress is not proportional to the rate of shear strain, is known as a Non-Newtonian fluid.

Ex: Paint, Toothpaste.

14. State Pascal's law. (CO1) (Understanding) (AU Nov '05)

It states that the pressure or intensity of pressure at a point in a static fluid is equal in all directions.

15. A soap bubble is formed when the inside pressure is 5 N/m^2 above the atmospheric pressure. If surface tension in the soap bubble is 0.0125 N/m, find the diameter of the bubble formed. (CO1) (Evaluating) (AU May '10)

16. The converging pipe with inlet and outlet diameters of 200 mm and 150 mm carries the oil whose specific gravity is 0.8. The velocity of oil at the entry is 2.5 m/s, find the velocity at the exit of the pipe and oil flow rate in kg/sec. (CO1) (Evaluating) (AU May '10)

17. What is specific gravity? How is it related to density? (CO1) (Analyzing) (AU April '08)

It is defined as the ratio of specific weight of fluid to specific weight of standard fluid. It can also be defined as the ratio of mass density of fluid to mass density of standard of fluid.

18. State Bernoulli's Theorem as applicable to fluid flow. (CO1) (Understanding) (AU May'04, Dec'07)

It states that an ideal incompressible fluid when the flow is steady and continuous, the sum of pressure energy, kinetic energy and potential energy is constant along the streamline.

$$\frac{P}{\rho g} + \frac{V^2}{2g} + z = Constant$$

19. Mention any three applications of Bernoulli's theorem. (CO1) (Understanding) (AU Dec'06)

(i) Venturimeter

(ii) Orifice meter

(iii) Pitot tube

20. **Why is co-efficient of discharge of venturimeter always greater than orifice meter? (CO1) (Rememdering)**
Loss of energy due to sudden enlargement is higher than loss of energy due to gradual contraction. So the co-efficient of discharge is greater for venturimeter than orifice meter
21. **Define specific weight of a liquid? (CO1) (Rememdering) (AU May'11)**
22. **Differentiate between steady and unsteady flow. (CO1) (Analyzing) (AU May'11)**
23. **Distinguish between solid and fluid. (CO1) (Analyzing) (AU Dec'11)**

PART – B

1. A 200 mm diameter shaft slides through a sleeve, 200.5 mm in a diameter and 400mm long at a velocity of 30 cm/s. The viscosity of the oil filling the annular space is $\mu = 0.1125$ NS/m^2. Find the resistance to the motion. (CO1) (Rememdering) (AU Dec'08)

2. A fluid of specific gravity 0.9 flows along a surface with a velocity profile given by $U = 4y - 8y^3$ m/s, Where y is in m. what is the velocity gradient at the boundary? If the kinematic viscosity is 0.36S, what is the shear stress at the boundary? (CO1) (Rememdering) (AU Dec'08)

3. The dynamic viscosity of oil, used for lubrication between a shaft and sleeve is 6poise. The diameter of the shaft is 0.4m and rotates at 190 rpm. Calculate the power lost in the bearing for a sleeve length of 90mm. Assume thickness of oil film as 1.5mm. (CO1) (Understanding) (AU Dec'07)

4. The capillary rise in a glass tube is not to exceed 0.2mm of water. Determine its minimum size, given that the surface tension for water in contact with air= 0.0725N/m. (CO1) (Understanding) (AU Dec'07)

5. The velocity distribution over a plate is given by $U = (3/4)\ y - y^2$, where u is velocity in m/s and at a depth y in m above the plate. Determine the shear stress at a distance of 0.3m from the top of plate. Assume dynamic viscosity of the fluid is taken as 0.95 NS/m^2. (CO1) (Understanding) (AU May'05)

6. A Newtonian fluid is filled in the clearance between a shaft and a concentric sleeve. The sleeve attains a speed of 50 cm/s, when a force of 40N is applied to the sleeve parallel to the shaft. Determine the speed of the shaft, if a force of 200N is applied. (CO1) (Evaluating) (AU Dec'05)

7. Calculate the capillary effect in millimeters in a glass tube of 4mm diameter, when immersed in (i) water and (ii) mercury, the temperature of liquid is 20^{o}C and the values of the surface tension of water and mercury at 20^{o}C in contact with air are 0.0735N/m and 0.51N/m respectively. The contact angle for water $\theta = 0$ and for mercury $\theta = 130^o$. Take specific weight of water at 20^{o}C as equal to 9790 N/m^3 and specific gravity of mercury is 13.6. (CO1) (Rememdering) (AU Dec'05, May'11, Dec'11)

8. State Bernoulli theorem for steady flow of an incompressible fluid. Derive an expression for Bernoulli equation and state the assumptions made. (CO1) (Understanding)

9. The space between two space parallel plates is filled with oil. Each side of the plate is 75cm. The thickness of the oil film is 10mm. The upper plate which moves at 3 m/s requires a force of 100N to maintain the speed. Determine:
   (i) The dynamic viscosity of the oil.
   (ii) The kinematic viscosity of the oil, if the specific gravity of the oil is 0.9. (CO1) (Evaluating) (AU Dec'04)

10. State Euler's equation of motion, in the differential form. Derive Bernoulli's equation from the above for the case of an 'ideal fluid flow'. (CO1) (Understanding) (AU May'07, May'11, Dec'11)

11. A horizontal venturimeter with inlet diameter 200 mm and throat diameter 100 mm is employed to measure the flow of water. The readings of the differential manometer connected to the inlet is 180 mm mercury. If C_d=0.98, determine the rate of flow. (CO1) (Evaluating)

12. (i) Draw the sectional view of a pitot's tube and write its concept to measure velocity of fluid flow? (CO1) (Understanding) (AU May'05)

(ii) A submarine fitted with a Pitot tube moves horizontally in sea. Its axis is 20 m below the surface of water. The Pitot tube placed in front of the submarine along its axis is connected to a differential mercury manometer showing a deflection of 20 cm. Determine the speed of the submarine. (CO1) (Evaluating) (AU May'05)

13. A horizontal venturimeter with inlet and throat diameter 300 mm and 100 mm respectively is used to measure the flow of water. The pressure intensity at inlet is 130 KN/m^2 while the vacuum pressure head at throat is 350 mm of mercury. Assuming that 3 percent head lost between the inlet and throat. Find the value of coefficient of discharge for the venturimeter and also determine the rate of flow. (CO1) (Evaluating) (AU Dec'05)

14. (i) An orifice meter with orifice diameter 15 cm is inserted in a pipe of 30 cm diameter. The pressure of the upstream and downstream of orifice meter is 14.7N/cm^2 and 9.81 N/cm^2. Find the discharge, if C_d=0.6. (CO1) (Understanding)

(ii) An oil of specific gravity 0.9 is flowing through a pipe of 20 cm diameter. An orifice meter with 10 cm diameter is inserted in the pipe to measure discharge. A differential U-tube mercury manometer connected to the orifice meter gives a pressure difference of 30 cm of mercury. Take C_d=0.65 for orifice meter. Find the discharge. (CO1) (Understanding)

15. Water is flowing through a tapering pipe having diameters 300 mm and 200mm at section 1 and 2 respectively. The discharge through the pipe is 400lpm. The sections 1 and 2 are 10 m and 8 m above the datum respectively. Determine the pressure at section 2 if the pressure at section 1 is 400 KN/cm^2. Assume there are no losses. (CO1) (Evaluating)

16. A 150 mm X 75 mm venture meter placed vertically with the throat 225 mm above the inlet conveys oil of specific gravity 0.78 at 29 lit/sec. Calculate the difference of pressure between the inlet and the throat. Take C_d=0.96 (CO1) (Evaluating)

17. Derive the equation of continuity for one dimensional flow. (CO1) (Evaluating)

18. Explain the relationship between absolute and gauge pressure. (CO1) (Evaluating) (AU Nov' 09)

19. Water is flowing through a pipe having a diameter 20 cm and 10 cm at section 1 and 2 respectively. The rate of flow through the pipe is 35 litres/sec. Section 1 is 6m above the datum and section2 is 4m above datum. If the pressure at section 1 is 39.24 N/cm^2. Find the intensity of pressure at section2. (CO1) (Understanding)

20. A 30 cm diameter pipe conveying water branches into two pipes of diameter 20 cm and 15 cm respectively. If the average velocity in the 30 cm diameter pipe is 2.5 m/sec. Find the discharge in the pipe. Also determine the velocity in 15 cm pipe if the average velocity in 20 cm diameter pipe is 2 m/sec. (CO1) (Evaluating) (AU Dec'09)

21. A capillary tube having inside diameter 6mm is dipped in CCl_4 at 20^{o}C. Find the rise of CCl4 in the tube if surface tension is 2.67N/M and specific gravity is 1.594 and contact angle is 60^o and specific weight of water at 20^{o}C is 9981N/m$^{3.}$ (CO1) (Understanding) (AU Dec'08)

22. A vertical cylinder of diameter 180mm rotates concentrically inside another cylinder of diameter 181.2mm. Both the cylinder are 300mm high. The space between the two cylinders is filled with liquid whose viscosity is unknown. Determine the viscosity of fluid if the torque of 20N-m is required to rotate the inner cylinder at 120 rpm. (CO1) (Evaluating) (AU May'07)

23. (i) Determine the viscosity of a liquid having a kinematic viscosity 6 stokes and specific gravity 1.9. (CO1) (Evaluating)

(ii) Prove that the relationship between surface tension and pressure inside a droplet of a liquid in excess of outside pressure is given by $P = 4\sigma/d$. (CO1) (Understanding)

24. In a vertical pipe conveying oil of specific gravity 0.8, two pressure gauges have been installed at 'A' and 'B', where the diameters are 160 mm and 80 mm respectively. 'A' is 2 metres above B. The pressure gauge readings have shown that the pressure at 'B' is greater than at 'A' by 0.981 N/cm^2. Neglecting all losses, calculate the flow rate. If the gauges at 'A' and 'B' are replaced by tubes filled with the same liquid and connected to a U- tube containing mercury. Calculate the difference in the level of mercury in the two limbs of the U- tube. (CO1) (Understanding) (AU Dec'07)

25. A 0.5 m shaft rotates in a sleeve under lubrication with viscosity 5 Poise at 200 rpm. Calculate the power lost for a length of 100 mm if the thickness of the oil is 1 mm. (CO1) (Understanding) (AU Dec'09)

26. A 400 mm diameter shaft rotating at 200 rpm in a bearing of length 120 mm. If the thickness of oil film is 1.5 mm and the dynamic viscosity of the oil is 0.7 Ns/m^2, determine (i) Torque require to overcome friction in bearing, (ii) Power utilized in overcoming viscous resistance. (CO1) (Evaluating) (AU May'11)

27. A horizontal venturimeter with inlet diameter 20 cm and throat diameter 10 cm is used to measure the flow of water. The pressure at inlet is 17.658 N/cm^2 and the vaccum pressure at the throat is 30 cm of mercury. Find the discharge of water through venturimeter. Take C_d = 0.98. (CO1) (Understanding) (AU May'11)

UNIT – II

FLOW THROUGH PIPES

PART – A

1. **Write down Hagen – Poiseuille equation for laminar flow. (CO2) (Understanding) (AU May'05)**

$$\frac{p_1 - p_2}{\rho g} = h_f = \frac{32\mu u L}{\rho g D^2}$$

2. **Enlist the various minor losses involved in a pipe flow system. (CO2) (Remembering) (AU May'05, Dec'09, May'11)**
   1. Loss of head due to sudden enlargement
   2. Loss of head due to sudden contraction
   3. Loss of head at the entrance to a pipe
   4. Loss of head at the exit of a pipe
   5. Loss of head due to an obstruction in a pipe
   6. Loss of head due to bend in the pipe
   7. Loss of head in various pipe fittings
3. **What is an equivalent pipe? (CO2) (Remembering) (AU Dec'06, May'11)**
   It is defined as the pipe of uniform diameter having loss of head and discharge equal to the loss of head and discharge of a compound pipe consisting of several pipes of different lengths and diameters.
4. **Write the formula for calculating loss of head due to**
   (a) Sudden enlargement
   (b) Sudden contraction (CO2) (Understanding) (AU Dec'09)

   Sudden Enlargement, $h_e = \frac{(V_1 - V_2)^2}{2g}$

   Sudden Contraction, $h_c = 0.5 \frac{V_2^2}{2g}$
5. **What are 'major' and 'minor' losses of flow through pipes? (CO2) (Remembering) (AU Dec'07, May'07)**
   The loss of head or energy due to friction in a pipe is known as major loss.
   The loss of energy due to change of velocity of the flowing fluid in magnitude or direction is called minor loss of energy.
6. **Define: Boundary layer and Boundary layer thickness. (CO2) (Remembering) (AU Dec'07, Dec'09, May'11, Dec'11)**
   Boundary Layer:
   If the boundary is stationary, the velocity of fluid at the boundary will be zero. Further away from the boundary, the velocity will be higher and as a result of this variation of velocity, the velocity gradient will exist. The velocity of fluid increases from zero velocity on the stationary boundary to free-stream velocity(U) of the fluid in the direction normal to the boundary. This variation of velocity from zero to free-stream velocity in the direction normal to the boundary takes place in a narrow region in the vicinity of solid boundary. The narrow region of the fluid is called boundary layer.
   Boundary layer thickness (δ):

It is defined as the distance from the boundary of the solid body measured in the y- direction to the point, where the velocity of the fluid is approximately equal to 0.99 times the free-stream velocity (U) of the fluid.

7. **Distinguish between: Hydraulic Gradient Line (HGL) and Total Energy Line (TEL). (CO2) (Analyzing) (AU May'07, May'05, May'11)**

   Hydraulic Gradient Line (HGL):

   It is defined as the line which gives the sum of pressure head and datum head of a flowing fluid in a pipe with respect to some reference line.

   Total Energy Line (TGL):

   It is defined as the line which gives the sum of pressure head, datum head and kinetic head of a flowing fluid in a pipe with respect to some reference line.
8. **Write down four examples of laminar flow. (CO2) (Understanding) (AU Dec'06)**
   1. Flow through pipes
   2. Blood flow through capillaries
   3. Laminar flow airfoil
   4. Laminar flow hood
9. **Sketch velocity distribution curve for laminar flows in a pipe. (CO2) (Understanding) (AU Dec'06)**

   Refer Page No.383 in R.K.Bansal

10. **Define the term Drag and lift. (CO2) (Remembering) (AU Dec'07, May'09)**

    The component of the total force in the direction of the flow of fluid is known as drag.

    The component of the total force in the direction perpendicular to the direction of the flow of fluid is known as lift.
11. **What are the uses of Moody's diagram? (CO2) (Remembering) (AU Dec'09)**

    It is used for determining friction factor for any turbulent flow problem. If the relative roughness of the pipe and Reynolds number are known.

12. **What do you mean by flow through parallel pipes? (CO2) (Remembering) (AU Dec'04)**

    When a main pipeline divides into two or more parallel pipes, which again join together to form a single pipe and continue as a main line.
13. **Define displacement thickness. (CO2) (Remembering) (AU Dec'04)**

    It is defined as the distance measured perpendicular to the boundary by which the mainstream is displaced to an account of formation of boundary layer.

14. **What is the physical significance of Reynold's number? (CO2) (Remembering) (AU Dec'07)**
    - (i) Motion of air planes.
    - (ii) Flow of incompressible fluid in closed pipes.
    - (iii) Motion of submarines
    - (iv) Flow around structures and other bodies immersed fully in moving fluids.
15. **Differentiate between the pipes in series and pipes in parallel. (CO2) (Analyzing)**

16. **State the criteria for laminar flow. (CO2) (Remembering)**

17. **What are pipes in series? (CO2) (Remembering)**

    It is defined as the pipe of different diameters and lengths are connected with one another to form a single pipeline.

18. Differentiate between laminar and turbulent flow. (CO2) (Analyzing) (AU Dec'05, Dec'11)

Laminar Flow	Turbulent flow
1. Fluid particles move in layers with one layer of fluid sliding smoothly over an adjacent layer. 2. Laminar flow occurs in the liquids having high viscosity. 3. This type of flow generally occurs in smooth pipes when velocity of flow is low. 4. There is no eddies or vortices present.	1. Fluid particles move in an entirely erratic manner. 2. This flow occurs in liquids having low viscosity. 3. This type of flow occurs in rivers, canals, streams, water supply pipes etc. 4. Eddies or vortices present in this type of flow.

PART – B

1. Prove that the head lost due to friction is equal to one third of the total head at inlet for maximum power transmission through pipes. (CO2) (Understanding)

2. Find the head loss due to friction in a pipe of diameter 30 cm and length 50 m, through which water is flowing at a velocity of 3m/sec. Using Darcy's formula. (CO2) (Understanding)

3. Oil of absolute viscosity 1.5 poise and density 848.3 Kg/m^3 flows through a 300 mm pipe. If the head loss in 3000 m length of pipe is 200 m, assuming a laminar flow, determine the following

1. The velocity
2. Reynolds number (CO2) (Evaluating)

4. A pipe line 2000 m long is used for power transmission. 110 Kw is to be transmitted through the pipe in which water having a pressure of $5000KN/m^2$ at inlet is flowing. If the pressure drop over a length of pipe is $1000KN/m^2$ and coefficient of friction is 0.0065, find the diameter of the pipe and efficiency of transmission. (CO2) (Understanding)

5. Three pipes of diameters 300mm, 200mm, 400mm and lengths 300 m, 170m and 210 m respectively are connected in series. The difference in water surface levels in two tanks is 12 m. Determine the rate of flow if co-efficient of friction are 0.005, 0.0052 and 0.0048 respectively considering (1) Minor losses, and (2) Neglecting minor losses. (CO2) (Evaluating)

6. Define: Boundary layer thickness(δ), displacement thickness(δ^*), Momentum thickness (θ) and Energy thickness (δ^{**}) (CO2) (Remembering) (AU Dec'07)

7. Find the displacement thickness, momentum thickness and energy thickness for the velocity distribution in the boundary layer given by : $(u/v) = (y/\delta)$, where 'u' is the velocity at a distance 'y' from the plate and $u = U$ at $y = \delta$, where δ = boundary layer thickness. Also calculate (δ^*/θ). (CO2) (Remembering) (AU Dec'07)

8. Two pipes of diameter 400mm and 200mm are each 300 m long. Where the pipes are connected in series the discharge through the pipe line is $0.10m^3/s$. Find the loss of head. What would the loss of head in the system to pass the same total discharge when the pipes are connected in parallel? Assume Darcy's friction factor as 0.0075. (CO2) (Remembering) (AU May'07)

9. (i) What is meant by critical Reynolds number? (CO2) (Remembering) (AU Dec'06)
(ii) Obtain a relationship between shear stress and pressure gradient? (CO2) (Understanding) (AU Dec'06)

10. (i) What is meant by equivalent pipe? (CO2) (Remembering) (AU Dec'06)
(ii) A 2500m long pipeline is used for transmission of power. 120Kw power is to be transmitted through the pipe in which water having a pressure of 4000KN/m^2 at inlet is flowing. If the pressure drop over the length of pipe is 800 KN/m^2 and f = 0.006. Find (1) Diameter of pipe, (2) Efficiency of transmission. (CO2) (Remembering) (AU Dec'06)

11. A laminar flow is taking place in pipe of diameter 20 cm. The maximum velocity is 1.5 m/s. Find the mean velocity and radius at which this occurs. Also calculate the velocity at 4 cm from the wall of pipe. (CO2) (Remembering) (AU May'09)

12. The rate of flow of water through a horizontal pipe is 0.25 m^3/sec. The diameter of the pipe which is 20 cm is suddenly enlarged to 40 cm. The pressure intensity in the smaller pipe is 11.772 N/cm^2. Determine:
1. Loss of head due to sudden enlargement,
2. Pressure intensity in larger pipe
3. Power loss due to enlargement. (CO2) (Evaluating) (AU May'09)

13. An oil of sp.gravity 0.7 is flowing through a pipe of diameter 30 cm at the rate of 500 litres/sec. Find the head lost due to friction and power required to maintain the flow for a length of 1000 m. Take γ = 0.29 stokes. (CO2) (Remembering) (AU May'09)

14. A jet plane which weights 29430 N and has a wing area of 20 m^2 flies at a velocity of 250 Km/hr. When the engine delivers 7357.5 KW. 65% of power is used to overcome the drag resistance of the wing. Calculate the coefficient of lift and coefficient of drag for the wing. Take density of air equal to 1.21kg/m^3. (CO2) (Remembering) (AU May'09)

15. Derive Hagen Poisuellies equation. (Or) Obtain an expression for Hagen Poisuellies equation for pressure difference between two sections in a pipe. (CO2) (Evaluating) (AU Dec'08, May'11)

16. A smooth two dimensional flat plate is exposed to a wind velocity of 100km/hr. If laminar boundary layer exists upto a value of R_N = 3X10^5, find the maximum distance up to which laminar boundary layer persists and find its maximum thickness. Assume kinematic viscosity of air as 1.49X$10^{-5}$$m^2$/s. (CO2) (Evaluating) (AU Dec'08)

17. A power transmission pipe 10 cm diameter and 500 m long is fitted with a nozzle at the exit, the inlet is from a river with water level 60 m above the discharge nozzle. Assume f = 0.02, calculate the maximum power which can be transmitted and the diameter of nozzle required. (CO2) (Remembering) (AU Dec'08)

18. (i)Derive Darcy Weisback equation for head loss due to friction in flow through pipe. What is the application of Darcy Weisback equation. (CO2) (Evaluating) (AU Dec'05 , Dec'09)
(ii) Distinguish between pipes connected in series and parallel? (CO2) (Analyzing) (AU Dec'05)

19. A pipe of 0.6m diameter is 1.5 km long. In order to augment the discharge, another line of the same diameter is introduced parallel to the first in the second half of the length. Neglecting minor losses. Find the increase in discharge if f = 0.04. The head at inlet is 40 m. (CO2) (Remembering) (AU Dec'05)

20. A pipe line 10km, long delivers a power of 50KW at its outlet ends. The pressure at inlet is $5000KN/m^2$ and pressure drop per km of pipeline is $50KN/m^2$. Find the size of the pipe and efficiency of transmission. Take 4f=0.02. (CO2) (Remembering) (AU Dec'05)

21. The velocity of water in a pipe 200mm diameter is 5m/s. The length of the pipe is 500m. Find the loss of head due to friction, if f = 0.008. (CO2) (Remembering) (AU Dec'05)

22. A horizontal pipe of 400 mm diameter is suddenly contracted to a diameter of 200 mm. The pressure intensities in the large and small pipe is given as $15N/cm^2$ and $10N/cm^2$ respectively. Find the loss of head due to contraction, if C_c= 0.62, determine also the rate of flow of water. (CO2) (Evaluating)

23. Air is flowing over a flat plate with a velocity of 5m/s. The length of the plate is 1.5 m and width 1m. The kinematic viscosity of air is given as 0.15 X 10^{-4} m^2/s. Find:

(i) The boundary layer thickness at the end of the plate

(ii) Shear stress at 20 cm from the leading edge and

(iii) Drag force on one side of the plate.

Take the velocity profile over a plate as u/U = sin (π/2xy/δand the density of air 1.24 kg/m^3. (CO2) (Remembering) (AU Dec'04)

24. Water flows through a 10 cm diameter, 30 m long pipe at a rate of 1400 lpm. What percent of head would be gained by replacing the central one third length of pipe by another pipe of 20 cm diameter. Assume that the changes in section are abrupt and f = 0.008 for all pipes. Neglect entrance and exit losses but consider all other losses. (CO2) (Remembering)

25. Two reservoirs whose water surface elevations differ by 12m are connected by the following horizontal compound pipe system starting from the high level reservoir. L_1 = 200 m, D_1 = 0.2 m, f_1 = 0.008 and L_2 = 500 m, D_2 = 0.2 m, f_2=0.006. Considering all head losses and assuming that all changes of section are abrupt, compute the discharge through the system. Determine the equivalent length of a 0.25 m diameter pipe if minor losses are neglected and friction factors are assumed to be same. Sketch HGL and TEL. (CO2) (Evaluating)

26. A 30 cm diameter pipe of length 30 m is connected in series to a 20 cm diameter pipe of length 20 m and conveys water. Determine the equivalent length of pipe of diameter 25 cm assuming that the friction factor remains the same and minor losses are negligible. (CO2) (Evaluating)

27. A thin plate is moving in still atmospheric air at a velocity of 5 m/s. The length of the plate is 0.6 m and width 0.5 m. Calculate (i) the thickness of the boundary layer at the end of the plate, and (ii) drag force on one side of the plate. Take the density of air as 1.24 Kg/m^3 and kinematic viscosity 0.15 strokes. (CO2) (Remembering) (AU Dec'09, May'11)

28. A main pipe divides into two parallel pipes, which again forms one pipe. The length and diameter for the first parallel pipe are 2000 m and 1 m respectively, while the length and diameter of second parallel pipe are 2000 m and 0.8 m respectively. Find the area of the flow in each parallel pipe, if total flow in the main is 3 m^3/s. The coefficient of friction for each parallel pipe is same and equal to 0.005. (CO2) (Remembering) (AU May'11)

29. A horizontal pipe line 40 m long is connected to a water tank at one end and discharges freely into the atmosphere at the other end. For the first 25 m of its length from the tank, the pipes is 150 mm diameter and its diameter is suddenly enlarged to 300 mm. The height of water level in the tank is 8 m above the centre of the pipe. Considering all losses of head, determine the rate of flow. Take f=0.01 for the both sections of the pipe. (CO2) (Remembering) (AU Dec'11)

30. Three pipes of 400 mm, 200 mm and 300 mm diameters have lengths of 400 m, 200 m, and 300 m respectively. They are connected in series to make a compound pipe. The ends of this compound pipe are connected with two tanks whose difference of water level is 16 m. If coefficient of friction for these pipes is same and equal to 0.005, determine the discharge through the compound pipe neglecting first the minor losses and then including them. (CO2) (Remembering) (AU Dec'11)

UNIT – III
DIMENSIONAL AND MODEL ANALYSIS
PART – A

1. **Define: Reynolds number and Froude number. (CO3) (Remembering) (AU Dec'07, Dec'09, May'11)**

   Reynolds Number: It is defined as the ratio of inertia force of a flowing fluid and the viscous force of the fluid.

   $$R_e = \frac{\rho V d}{\mu}$$

   Froude Number: It is defined as the square root of the ratio of inertia force of a flowing fluid to the gravity force.

   $$F_e = \sqrt{\frac{F_i}{F_g}}$$

2. **What are the types of similarities? (CO3) (Remembering)**

   (i) Geometric Similarities
   (ii) Kinematic Similarities
   (iii) Dynamic Similarities

3. **Define: Mach number and Euler number. (CO3) (Remembering) (AU May'07, Dec'09, May'11)**

   Mach Number (M): It is defined as the square root of the ratio of inertia force of a flowing fluid to the elastic force.

   $$M = \sqrt{\frac{F_i}{F_e}}$$

   Euler Number: It is defined as the the square root of the ratio of inertia force of a flowing fluid to the pressure force.

   $$E_u = \sqrt{\frac{F_i}{F_p}}$$

4. **What is similarity in model study? (CO3) (Remembering) (AU May'05)**

   It is defined as the similarity between the model and its prototype in every respect, which means that the model and prototype have similar properties or model and prototype are completely similar.

5. **What is scale effect in physical model study? (CO3) (Remembering) (AU Dec'05)**

It is impossible to product the exact behavior of the prototype by model testing alone. The two models of same prototype behavior will be different. Scale ratios will not be same. So discrepancy between models and prototype will always occur. It is known as scale effect.

6. **Explain the term dimensionally homogeneous equation and give an example? (CO3) (Understanding) (AU May'09, Dec'04)**
Dimensional homogeneity means the dimensions of each terms in an equation on both sides equal. Thus if the dimensions of each term on both sides of an equation are the same the equation is known as dimensionally homogeneous equation.
Consider equation, $V = \sqrt{2gH}$
Dimension of L.H.S = V = LT^{-1}

Dimension of R.H.S = $\sqrt{2gH} = \sqrt{LT^{-2} \times L} = LT^{-1}$

Dimension of L.H.S = Dimension of R.H.S

7. **What is meant by undistorted models? (CO3) (Remembering)**
Undistorted models are those models which are geometrically similar to their prototype or if the scale ratio for the linear dimensions of the model and its prototype is same, the model is called undistorted model.
8. **State the advantages of Dimensional and model analysis. (CO3) (Remembering) (AU May'09, May'11)**
   1. The performance of the hydraulic structure or hydraulic machine can be easily predicted, in advance, from its model.
   2. With help of dimension analysis, a relationship between the variables influencing a flow problem in terms of dimensionless parameters is obtained. This relationship helps in conducting tests on the model.
   3. The merits of alternative designs can be predicated
9. **What is meant by dynamic similarity? (CO3) (Remembering) (AU Dec'08, Dec'09)**
Dynamic similarity means the similarity of forces between the model and prototype. Thus dynamic similarity is said to exist between the model and the prototype if the ratios of the corresponding forces acting at the corresponding points are equal.
10. **What are the applications of model testing? (CO3) (Remembering)**
    (i) Civil Engineering structures such as dams, weirs, canals etc
    (ii) Design of harbor, ships and submarines
    (iii) Aero planes, rockets and machines, missiles

11. **What do you understand by fundamental units and derived units? (CO3) (Remembering) (AU May'10)**
Length L, mass M and time T are three fixed dimensions which are of importance in Fluid Mechanics. These fixed dimensions are called fundamental dimensions or fundamental quantity.
Secondary or derived quantities are those quantities which posses more than one fundamental dimension. For example, velocity is denoted by distance per unit time (L/T), density by mass per unit volume (M/L^3).
12. **State a few applications/usefulness of 'dimensional analysis'. (CO3) (Remembering) (AU May'07)**

13. **Explain Rayleigh's method. (CO3) (Understanding) (AU Dec'09)**

14. **State: Buckingham's π theorem. (CO3) (Remembering) (AU Dec'06, May'11)**

It states that if there are 'n' variables in a dimensionally homogeneous equation and if these variables contain 'm' fundamental dimensions (M, L, T), then they are grouped into (n-m), dimensionless independent π – terms.

15. State three demerits of a distorted model. (CO3) (Remembering)

(i) Exit pressure and velocity distributions are not true.

(ii) A model wave may differ from that of proto type.

(iii) Both extrapolation and interpolation of results are difficult.

16. Give the dimensions of the following physical quantities: (a) Pressure, (b) Surface tension, (c) Dynamic viscosity, (d) Kinematic viscosity. (CO3) (Remembering)

(a) Pressure – $ML^{-1}T^{-2}$ (c) Surface tension - MT^{-2}

(b) Dynamic viscosity - $ML^{-1}T^{-1}$ (d) Kinematic viscosity – L^2T^{-1}

17. Differentiate distorted and undistorted model in dimensional analysis. (CO3) (Analyzing) (AU Dec'09)

18. Define geometric similarity. (CO3) (Remembering) (AU Dec'09)

The geometric similarity is said to exist between the model and the prototype. The ratio of all corresponding linear dimension in the model and prototype are equal.

19. Give the applications of Euler's model. (CO3) (Remembering) (AU Dec'09)

Euler's model law is applied for fluid flow problems where flow is taking place in a closed pipe in which case turbulence is fully developed so that viscous forces are negliglible and gravity force and suface tension force is absent. This law is also used where the phenomenon of cavitation takes place.

20. Define: Kinematic similarity. (CO3) (Remembering) (AU May'11)

21. Define the terms (a) Dimensional analysis (b) Model analysis. (CO3) (Remembering) (AU Dec'11)

22. What do you mean by dimensionless numbers? Name any four dimensionless numbers. (AU Dec'11) (CO3) (Remembering)

PART – B

1. State: Buckingham's π theorem. What are the considerations in the choice of repeating variables? Write down the procedure for solving problems by using Buckingham's π theorem. (CO3) (Remembering) (AU Dec'07, Dec'09).

2. Resistance R, to the motion of a completely submerged body is given by

$R = \rho v^2 l^2 \Phi (VL / \gamma)$, where 'ρ' and 'γ' are the mass density and kinematic viscosity of the fluid, v – velocity of flow, l – length of the body.

If the resistance of a one-eighth scale air-ship model when tested in water at 12 m/s is 22 N, what will be the resistance of the air-ship at the corresponding speed in air? Assume kinematic viscosity of air is 13 times that of water and density of water is 810 times of air. (CO3) (Remembering) (AU Dec'07)

3. (i) What are 'repeating variables'? How are these selected? (CO3) (Remembering) (AU May'07)

(ii) What is meant by geometric, kinematic and dynamic similarities? (OR) Explain the different types of similarities that must exist between a prototype and its model. (CO3) (Remembering)

(iii) Define Dimensional homogeneity. (AU May'07) (CO3) (Remembering)

4. In an aero plane model of size (1/10) of its prototype, the pressure drop is $7.5 KN/m^2$. The model is tested in water. Find the corresponding drop in the prototype. Assume, density of air = $1.24 kg/m^3$, density of water = 1000 kg/m^3, viscosity of air = 0.00018 poise, viscosity of water = 0.01 poise. (CO3) (Understanding) (AU May'07, Dec'11)

5. Using Buckingham's π theorem, show that velocity, through a circular pipe orifice is given by

$$V = \sqrt{2gH}\, \Phi (D/H, \mu/ \rho v H)$$

H – Head causing flow, D – dia of orifice, μ - co efficient of viscosity, ρ- mass density, g – acceleration due to gravity. (CO3) (Understanding) (AU Dec'06)

6. Model of an air duct operating with water produces a pressure drop of 10KN/m^2 over 10 m length. If the scale ratio is 1/50. Density of water is 1000 kg/m^3 and density of air is 1.2 kg/m^3. Viscosity of water is 0.001 Ns/m^2 and viscosity of air is 0.00002 Ns/m^2. Estimate corresponding drop in a 20 m long air duct. (CO3) (Evaluating) (AU Dec'05)

7. The resisting force (R) of a supersonic flight can be considered as dependent upon the length of the air craft 'l', velocity 'v', air viscosity 'μ', air density'ρ' and bulk modulus of air is 'k'. Express the functional relationship between these variables and the resisting force. (CO3) (Understanding) (AU Dec'05)

8. The frictional torque T of a disc of diameter D rotating at a speed N in a fluid of viscosity μ and density ρ in a turbulent flow is given by (AU Dec'04, May'11)

$T = D^5 N^2 \rho\, \Phi (\mu / D^2 N \rho)$ Prove this by Buckingham's π theorem. (CO3) (Understanding)

9. (i) Determine the dimensions of the following quantities: (CO3) (Understanding)
Discharge, Kinematic viscosity, Force and Specific weight, Dynamic viscosity
(ii) What are distorted models? What are the merits and demerits of distorted models? (CO3) (Understanding)

10. Derive a fundamental relation for change in pressure of liquid flowing through a pipe having diameter 'D', length, density, viscosity, roughness and velocity. Also deduce expression for head loss due to turbulence. (CO3) (Evaluating)

11. The ratio of length of submarine and its model is 30:1. The speed of submarine (proto type) is 10 m/s. The model is to be tested in wind tunnel. Find the speed of air in wind tunnel. Also determine the ratio if drag force required between model and its prototype. Take the following data. Kinematic viscosity of Sea water is 0.012 stokes, Density of Sea water is 1030 kg/m^3, Kinematic viscosity of Air is 0.016 Stokes, and density of Air is 1.24 kg/m^3. (CO3) (Evaluating) (AU May'11)

12. The efficiency (η) of a fan depends on ρ (density), μ (viscosity) of the fluid, ω (angular velocity), d (diameter of rotor) and Q (discharge). Express η in terms of non-dimensional parameters. Use Buckingham's π theorem. (CO3) (Evaluating) (AU May'10, Dec'09, Dec'11)

13. State Euler's Model law. (CO3) (Evaluating) (AU Dec'11)

UNIT – IV

HYDRAULIC TURBINES

PART – A

1. **How are Hydraulic turbines classified? (CO4) (Remembering) (AU May'09)**
   The hydraulic turbines are classified according to the
   (i) type of energy available at the inlet of the turbine
   (ii) direction of flow through the vanes,
   (iii) head at the inlet of the turbine
   (iv) Specific speed of the turbine.

2. **Define Specific speed of a turbine. (N_s) What is its usefulness? (CO4) (Remembering) (AU Dec'07, May'09, May'11, Dec'11)**
   It is defined as the speed of a turbine which is identical in shape, geometrical dimensions, blade angles, get opening etc., with the actual turbine but of such a size that it will develop unit power when working under unit head.
   Specific speed of a turbine is defined as the speed at which a turbine runs when it is working under a unit head and develops unit power.
   The specific speed plays as important role for selecting the type of the turbine and also the performance of a turbine can be predicated by the knowing the specific speed of the turbine.
3. **Draw velocity triangle diagram for Pelton Wheel Turbine. (CO4) (Understanding)**

4. **Differentiate between pumps and turbines. (CO4) (Analyzing) (AU Dec'07, May'07)**

Turbines	Pumps
1. Turbine converts hydraulic energy into mechanical energy.	1. Pump converts mechanical energy into hydraulic energy.
2. It is energy producing machine.	2. It is energy absorbing machine.
3. Flow takes place from high pressure side to the low pressure side.	3. Flow takes place from low pressure side to the high pressure side.

5. **Define hydraulic efficiency of a turbine. (CO4) (Remembering) (AU Dec'06)**
   It is defined as the ratio of power given by water to the runner of a turbine to the power supplied by the water at the inlet of the turbine.

$$\eta_h = \frac{\text{Power delivered to runner}}{\text{Power supplied at inlet}}$$

6. **What is a draft tube and Write the function of draft tube in turbine outlet? (CO4) (Remembering) (AU Dec'09, May'11)**
   The draft tube is a pipe of gradually increasing area which connects the outlet of the runner to the tail race. It is used for discharging water from the exit of the turbine to the tail race. This pipe of gradually increasing area is called a draft tube.

Function of draft tube: It converts a large proportion of the kinetic energy rejected at the outlet of the turbine into useful pressure energy.
By using draft tube, the net head on the turbine increases. The turbine develops more power and also the efficiency of the turbine increases.

7. Classify turbines according to flow. (CO4) (Remembering) (AU Dec'05)

(i) Tangential flow turbine
(ii) Radial flow turbine
(iii) Axial flow turbine
(iv) Mixed flow turbine

8. What are high head turbines? Give examples. (CO4) (Remembering) (AU Dec'09)

9. The mean velocity of the buckets of the pelton wheel is 10 m/s. The jet supplies water at 0.7 m^2/s at a head of 30 m. The jet is deflected through an angle of 160^o by the bucket. Find the hydraulic efficiency. Take $C_v = 0.98$ (CO4) (Remembering) (AU May'10)

10. Define degree of reaction. (CO4) (Remembering)

It is defined as the ratio between the kinetic energy change in the moving blade to the kinetic energy change in stage.

11. Differentiate the impulse and reaction turbine. (CO4) (Analyzing) (AU May'08)

Impulse Turbine	Reaction Turbine
1. All the potential energy is converted into kinetic energy by nozzle before entering to turbine runner.	1. Only a portion of the fluid energy transferred into kinetic energy before the fluid enters the turbine.
2. Blades are only in action when they are in front of nozzle.	2. Blades are in action at all the time.

12. Write the expression used to find the jet ratio in a pelton wheel. (CO4) (Remembering) (AU Dec'09)

It is defined as the ratio of the pitch diameter (D) of the pelton wheel to the diameter of the jet (d). It is denoted by 'm'.

$$m = D/d$$

PART – B

1. A Pelton wheel has a mean bucket speed of 10 meters per second with a jet of water flowing at the rate of 700 litres/sec under a head of 30 meters. The buckets deflect the jet through an angle of 160^o. Calculate the power given by water to the runner and the hydraulic efficiency of the turbine. Assume coefficient of velocity 0.98. (CO4) (Analyzing) (AU May'09)

2. Obtain an expression for the work done per second by water on the runner of a pelton wheel and draw inlet and outlet velocity triangles for a pelton turbine and indicate the direction of various velocities. (CO4) (Understanding) (AU May'09)

3. (i) A Kaplan turbine runner is to be designed to develop 7357.5KW shaft power. The net available head is 5.50m. Assume that the speed ratio is 2.09 and flow ratio is 0.68, and overall efficiency is 60%. The diameter of the boss is $1/3^{rd}$ of the diameter of the runner. Determine the diameter of the runner, its speed and its specific speed. (CO4) (Analyzing) (AU May'09, May'11)

(ii) Derive an expression for Specific speed. What is the significance of specific speed of turbine? (CO4) (Understanding) (AU May'09)

4. (i) Classify hydraulic machines and give one example for each. (CO4) (Remembering) (AU Dec'08)
(ii) Explain the working principle of Kaplan turbine and derive the working proportion of its design. (CO4) (Understanding) (AU Dec'08)
5. (i) Write a short note on Governing of Turbines. (CO4) (Understanding) (AU Dec'08)
(ii) Design a Francis Turbine runner with the following data: Net head=70m.
Speed N = 800rpm. Output power = 400Kw. Hydraulic efficiency = 95%. Over efficiency = 85%. Flow ratio = 0.2. Breadth ratio = 0.1. Inner diameter is 1/3 outer diameter. Assume 6% circumferential area of the runner to be occupied by the thickness of the vanes. The flow is radial at exit and remains constant throughout. (CO4) (Evaluating) (AU Dec'08)

6. (i) Define: Hydraulic efficiency and overall efficiency with respect to turbines.
(i) What is a 'breaking jet' in a Pelton wheel/turbine? (AU Dec'07)
(iii) A Pelton wheel is to be designed for the following specifications:
Shaft power = 11,772 Kw
Head (H) = 380 metres
Speed = 750 rpm
Overall efficiency (η_o) = 86%
Jet diameter > 1/6 wheel diameter. (AU Dec'07)
Determine: The wheel diameter, the number of jets required and diameter of the jet. (CO4) (Analyzing)
7. (i) State the expression for the Specific speed of a pump. What is its use? (CO4) (Understanding) (AU Dec'07)
(ii) The outer diameter of an impeller of a centrifugal pump is 400mm and outlet with is 50mm. The pump is running at 800rpm and its working against a total head of 15m. The vanes angle at outlet is 40^o and the manometric efficiency is 75%. Determine: the velocity of flow at inlet, velocity of water leaving the vane, angle made by the absolute velocity at outlet with the direction of motion at outlet, and the discharge. (CO4) (Analyzing) (AU Dec'07)

8. A single jet Pelton wheel runs at 300rpm under a head of 510m. The jet diameter is 200mm and its deflection inside the bucket is 165^o. Assuming that its relative velocity is reduced by 15% due to friction, determine: (1) water power (2) resultant force on bucket and (3) overall efficiency. (CO4) (Analyzing) (AU May'07)

9. (i) Sketch velocity triangles at inlet and outlet of a pelton wheel. (CO4) (Understanding) (AU Dec'06)
(ii) A Pelton wheel has to be designed for the following data. Power to be developed = 6000Kw. Net head available = 300m, Speed = 500rpm. Ratio of jet diameter to wheel diameter = 1/10 and overall efficiency = 85%. Find the number of jets, diameter of the jet, diameter of the wheel and the quantity of water required. (CO4) (Understanding) (AU Dec'06)

10. (i) Derive an expression for the efficiency of a draft tube. (CO4) (Understanding) (AU Dec'06)

(ii) Calculate the diameter and speed of the runner of a Kaplan turbine developing 6000Kw under an effective head of 5m. Overall efficiency of the turbine is 90%. The diameter of the boss is 0.4 times the external diameter of the runner. The turbine speed ratio is 2.0 and flow ratio 0.6. (CO4) (Understanding) (AU Dec'06)

11. (i) Differentiate Pelton wheel turbine with Francis Turbine. (CO4) (Analyzing)

(ii) The nozzle of a pelton wheel gives a jet of 9 cm diameter and velocity 75m/s. Coefficienct of velocity is 0.978. The pitch circle diameter is 1.5m and the deflection angle of the buckets is 170 degree. The wheel velocity is 0.46 times the jet velocity. Estimate the speed of the Pelton wheel turbine in rpm, theoretical power developed and also the efficiency of the turbine. (CO4) (Evaluating)

12. (i) What is draft tube? Why it is necessary in reaction turbine? (CO4) (Understanding)
(ii) Explain the terms unit power, unit speed and unit discharge with reference to a turbine. (CO4) (Understanding)
(iii) Define cavitation. What are the effects of cavitation. Give the necessary precaution against cavitation. (CO4) (Remembering) (AU Dec'11)

13. The external and internal diameters of an inward flow reaction turbines are 1.20 m and 0.6 m respectively. The head on the turbine is 22 m and velocity of flow through the runner is constant and equal to 2.5 m/s. The guide blade angle is given as 10^o and runner vanes are radial at inlet. If the discharge at outlet is radial, determine: (i) the speed of turbine, (ii) the vane angle at outlet of the runner, (iii) Hydraulic efficiency. (CO4) (Evaluating) (AU May'11).

14. An inward flow reaction turbine has external and internal diameters as 1.0 m and 0.6 m respectively. The hydraulic efficiency of the turbine is 90% when the head on the turbine is 36 m. The velocity of flow at outlet is 2.5 m/s and discharge at outlet is radial. If the vane angle at outlet is 15^o and width of the wheel is 100 mm at inlet and outlet, determine (i) the guide blade angle, (ii) Speed of the turbine, (iii) Vane angle of the runner at inlet, (iv) Volume flow rate of turbine and (v) Power developed. (CO4) (Evaluating) (AU Dec'11)

UNIT – V
HYDRAULIC PUMPS
<u>PART – A</u>

1. **Distinguish between pumps in series and pumps in parallel. (CO5) (Analyzing)**
   For developing a high head, a number of impellers are mounted in series or on the same shaft.
   For obtaining high discharge, the pumps should be connected in parallel.
2. **Define specific speed of centrifugal pump. (CO5) (Understanding) (AU Dec'09, Dec'11)**
   Specific speed of a centrifugal pump is defined as the speed of a geometrically similar pump which would deliver one cubic metre of liquid per second against a head of one metre.
3. **Define: Manometric efficiency of the centrifugal pump. (CO5) (Understanding) (AU Dec'07, May'11)**
   The ratio of the manometric head to the head imparted by the impeller to the water is known as manometric efficiency.

Manometric head

η_{mano} = $\frac{}{\text{Head imparted by impeller to water}}$

4. **What is meant by priming of pump? Why is it necessary? (CO5) (Understanding) (AU May'08, May'11)**
   Priming of a centrifugal pump is defined as the operation in which the suction pipe, casing of the pump and a portion of the delivery pipe up to the delivery valve is completely filled up from outside source with the liquid to be raised by the pump before starting the pump.
5. **What is the role of a volute chamber of a centrifugal pump? (CO5) (Remembering) (AU Dec'05, Dec'11)**
   (ii) To guide water to and from the impeller
   (iii) To partially convert the kinetic energy into pressure energy.
6. **Classify pumps on the basis of transfer of mechanical energy. (CO5) (Understanding) (AU Dec'06)**
   (i) Single stage centrifugal pumps.
   (ii) Multi-stage centrifugal pumps.
7. **Define Manometric head. (CO5) (Remembering) (AU Dec'09)**
   The manometric head is defined as the head against which a centrifugal pump has to work. It is denoted by "H_m".

8. **What are the effects of Cavitation? (CO5) (Understanding) (AU May'11)**
9. **What are the functions of Air Vessel? (CO5) (Understanding) (AU May'09, May'11)**
   An air vessel is fitted to the suction pipe and delivery pipe at a point close to the cylinder of a single – acting reciprocating pump:
   (i) To obtain a continuous supply of liquid at a uniform rate
   (ii) To save a considerable amount of work in overcoming the frictional resistance in the suction and delivery pipes.
   (iii) To run the pump at a high speed without separation.
10. **When do negative slip occur? (CO5) (Understanding) (AU Dec'08, May'11)**
    Negative slip occurs when delivery pipe is short, suction pipe is long and pump is running at high speed.
11. **Define: 'Indicator Diagram'. (CO5) (Remembering) (AU Dec'07, May'07, Dec'09, May'11)**
    It is defined as the graph between the pressure head in the cylinder and stroke length of the piston for one complete revolution.
12. **Distinguish between centrifugal pump and reciprocating pump. (CO5) (Analyzing)**

Centrifugal Pump	Reciprocating Pump
1. The discharge is continuous and smooth. 2. It can handle large quantity of liquid. 3. Efficiency is high. 4. It is used for large discharge through smaller heads.	1. The discharge is fluctuating and pulsating. 2. It handles small quantity of liquid only. 3. Efficiency is low. 4. It is meant for small discharge and high speeds.

13. When will you select a reciprocating pump? (CO5) (Understanding) (AU Dec'05)
For obtaining high pressure or head and low discharge, a reciprocating pump is selected.

14. What is negative slip in a reciprocating pump? ((CO5) (Remembering) (AU May'11)
If actual discharge is more than the theoretical discharge, the slip of the pump will become negative. In that case, the slip of the pump is known as negative slip.

15. Define slip and percentage of Slip of the reciprocating pump. (CO5) (Remembering) (AU Dec'08, May'10, Dec'09)
Slip of a pump is defined as the difference between theoretical discharge and actual discharge the pump.

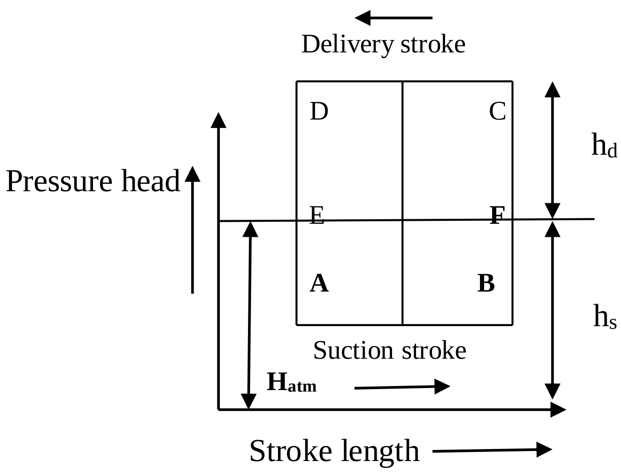
$$\text{Slip} = Q_{th} - Q_{act}$$

Slip is mostly expressed as percentage of slip.

$$\text{Percentage slip} = \frac{Q_{th} - Q_{act}}{Q_{th}} \times 100$$

16. What are rotary pumps? Give examples. (CO5) (Remembering)
Rotary pumps resemble like a centrifugal pumps in appearance. But, the working method differs. Uniform discharge and positive displacement can be obtained by using these rotary pumps. It has the combined advantages of both Centrifugal and Reciprocating Pumps.

17. Draw the Ideal indicator diagram. (CO5) (Understanding)



18. What are the advantages of centrifugal pump over reciprocating pump? (CO5) (Remembering) (AU May'09)
19. What is the application of an air vessel? (CO5) (Remembering) (AU Dec'09)
20. What is an air vessel in reciprocating pump? (CO5) (Remembering) (AU Dec'11)

PART – B

1. (i) Explain the working principle of reciprocating pump with neat sketch. (CO5) (Understanding) (AU Dec'09)
(ii) Explain the working principle of Gear pump with neat sketch. (CO5) (Understanding)

2. A double acting pump with 35cm bore and 40cm stroke runs at 60 strokes per minute. The suction pipe is 10m long and delivery pipe is 200m long. The diameter of the delivery pipe is 15cm. The pump is

situated at a height of 2.5m above the sump; the outlet of delivery pipe is 70m above the pump. Calculate the diameter of the suction pipe for the condition that separation is avoided. Assume separation to occur at an absolute pressure head is 2.5m of water. Find the Horsepower required to drive the pump neglecting all losses other than friction in the pipes assuming friction factor f as 0.02. (CO5) (Understanding) (AU Dec'08)

3. A single – acting reciprocating pump is to raise a liquid of density 1200Kg/m^3 through a vertical height of 11.5 metres, from 2.5 metres below pump axis to 9 metres above it. The plunger, which moves with SHM, has diameter 125mm and 225mm. The suction and delivery side pipes are 75 mm diameter and 3.5 and 13.5 metres long, respectively. There is a large air vessel fitted on the delivery pipe near the pump axis, but, there is no air vessel on the suction pipe. If separation takes place at 8.829 N/cm^2 below atmospheric pressure, find: the maximum speed at which the pump can be run without separation taking place and the power required to drive the pump. Assume there is 'no slip' in the pump and f = 0.08. (CO5) (Understanding) (AU Dec'07)

4. (i) What is an 'Air Vessel'? What are the uses/advantages of fitting air vessels in a reciprocating pump and write the expression for work done by the reciprocating pump fitted with Air vessel. (CO5) (Remembering) (AU Dec'07)
   (iv) Define percentage of Slip and indicator diagram, with respect to a reciprocating pump. (CO5) (Understanding)

5. A single-acting reciprocating pump has a plunger diameter of 250mm and stroke of 450mm. It is driven at 60 rpm and undergoes SHM. The length and diameter of the delivery pipe are 60m and 100mm respectively. Determine the power saved in overcoming the friction in the delivery pipe, due to fitting of an air vessel on the delivery side of the pump. Assume the friction factor f= 0.01. (AU Dec'07) (CO5) (Evaluating)

6. The diameter and stroke length of a single-acting reciprocating pump are 75mm and 150mm respectively. Supply of water to the pump is from a sump 3m below the pump through a pipe 5m long and 40mm in diameter. The pump delivers the water to a tank located at 12m above the pump through a pipe 30mm in diameter and 15m long. Assuming that separation of flow occurs at 75KN/m^2 (below the atmospheric pressure), find the maximum speed at which the pump may be operated without any separation. Assume that the piston executes a simple harmonic motion. (CO5) (Remembering) (AU May'07)

7. A double-acting reciprocating pump is running at 30 rpm. Its bore and stroke are 250mm and 400mm respectively. The pump lifts water from a sump 3.8m below and delivers it to a tank located at 65m above the axis of the pump. The length of suction and delivery pipes are 6m and 150m respectively. The diameter of the delivery pipe is 100mm. If an air vessel of adequate capacity has been fitted on the delivery side of the pump, determine: (1) the minimum diameter of the suction pipe to prevent separation of flow, assuming the minimum head to prevent occurrence of separation is 2.5m, (2) the maximum gross head against which the pump has to work and the corresponding power of motor. Assume the mechanical efficiency = 78% and slip = 1.5%; H atm = 10.0 m; F = 0.012. (CO5) (Evaluating) (AU May'07)

8. The cylinder bore diameter of a single acting reciprocating pump is 150mm and its stroke length is 300mm. The pump runs at 50 rpm and lifts water through a height of 25m. The delivery pipe is 22m long and 100 mm in diameter. Find the theoretical discharge and the theoretical power required to run

the pump. If the actual discharge is 4.2 litres/s, find the percentage slip. (CO5) (Evaluating) (AU Dec'05)

9. The length and diameter of a section pipe of a single acting reciprocating pump are 5m and 10 cm respectively. The pump has a plunger of diameter 150 mm and of stroke length 300mm. The centre of the pump is 4 m above the water surface in the pump. The atmospheric pressure head is 10.3 m of water and pump is running at 40rpm. Determine:
   (i) Pressure head due to acceleration at the beginning of the suction stroke.
   (ii) Maximum pressure head due to acceleration.
   (iii) Pressure head in the cylinder at the beginning and at the end of the stroke. (CO5) (Evaluating) (AU May'11)

10. What is a reciprocating pump? Describe the principle and working of a double acting reciprocating pump with a neat sketch. (CO5) (Remembering)

11. How rotary pumps are classified. Explain the working principles of any one type of rotary pump with the aid of a neat sketch. (CO5) (Remembering)

12. A single acting reciprocating pump running at 50 rpm delivers $0.01m^3$/sec of water. The diameter of the piston is 20cm and stroke length 40 cm. Determine:
   (i) The theoretical discharge of the pump
   (ii) Co-efficient of discharge
   (iii) Slip of the pump. (CO5) (Evaluating)

13. A single acting reciprocating pump has a plunger of diameter 300mm and stroke of 200mm. If the speed of the pump is 30 rpm and the actual discharge is 6.5 litres per second of water, find the coefficient of discharge and percentage slip, if overall efficiency is 75%. What horse power is required to drive the pump. If the suction lift is 4m and delivery head is 30m. (CO5) (Evaluating)

14. The diameter and stroke of a single acting reciprocating pump are 120 mm and 300 mm respectively. The water is lifted by a pump through a total head of 25 m. The diameter and length of delivery pipe are 100 mm and 20 m respectively. Find out:
   (i) Theoretical discharge and theoretical power required to run the pump if its speed is 60 rpm.
   (ii) Percentage slip, if the actual discharge is 2.95 l/s and
   (iii) The acceleration head at the beginning and middle of the delivery stroke. (CO5) (Evaluating) (AU May'10)

15. Explain the working of the following pumps with the help of neat sketches and mention two applications of each. (CO5) (Remembering)
   (i) External gear pump , (ii) Lobe pump, (iii) Vane pump, (iv) Screw pump (AU May'10)

16. What is a reciprocating pump? Describe the principle and working of a reciprocating pump with a neat sketch. Why is a reciprocating pump not coupled directly to the motor? Discuss in detail. (CO5) (Remembering) (AU Dec'11)

17. A single acting reciprocating pump has a plunger of diameter 100 mm and stroke length of 200 mm. The centre of the pump is 3 m above the water level in the sump and 20 m below the water level in a tank to which water is delivered by the pump. The diameter and length of suction pipe are 50 mm and 5 m while that of the delivery pipe are 40 mm and 30 m respectively. Determine the maximum speed at

which the pump may be run without separation, if a separation occurs at 7.3575 N/cm^2 below the atmospheric pressure. Take atmospheric pressure head = 10.3 m of water. (CO5) (Evaluating) (AU Dec'11)

18. (i) What is priming? Why is it necessary? (CO5) (Remembering) (AU May'09)
    (ii) A single stage centrifugal pump with impeller diameter of 30cm rotates at 2000rpm and lifts $3m^3$ of water per second to a height of 30m with an efficiency of 75%. Find the number of stages and diameter of each impeller of a similar multistage pump to lift $5m^3$ of water per second to a height of 200meters when rotating at 1500 rpm. (CO5) (Evaluating) (AU May'09)
19. A centrifugal pump having outer diameter equal to 2 times the inner diameter and running at 1200rpm works against a total head of 75m. The velocity of flow through the impeller is constant and equal to 3m/s. The vanes are set back at an angle of 30^o at outlet. If the outer diameter of the impeller is 600mm and width at outlet is 50mm. Determine: (i) Vane angle at Outlet, (ii) Work done per second by impeller, (iii) Manometric efficiency. (CO5) (Evaluating) (AU May'11)

20. The internal and external diameters of the impellers of a centrifugal pump are 20cm and 40cm respectively. The pump is running at 1200 rpm. The vane angles of the impeller at inlet and outlet are 20^o and 30^o respectively. The water enters the impeller radially and velocity of flow is constant. Determine the work done by the impeller per kg of water. (CO5) (Evaluating) (AU Dec'09)
21. The impeller of a centrifugal pump is 300mm in diameter and having a width of 50mm at the pheriphery. It has blades whose tip angles are inclined backwards at 60^o from the radius. The pump delivers $17m^3$/min of water and the impeller rotates at 1000rpm. Assuming that the pump is designed to admit liquid radically, calculate: (1) speed and direction of water as it leaves impeller (2) torque exerted by the impeller on water (3) shaft power required (4) lift of the pump. Assume the mechanical efficiency = 95% and hydraulic efficiency = 75%. (CO5) (Evaluating) (AU May'07)

22. The impeller of a centrifugal pump has an external diameter of 450mm and internal diameter of 200mm and it runs at 1440rpm. Assuming a constant radial flow through the impeller at 2.5m/sec and that the vanes at exit are set back at an angle of 25^o. Determine: (1) Inlet vane angle, (2) The angle, absolute velocity of water at exit makes with the tangent and (3) The work done per N of water. (CO5) (Evaluating) (AU Dec'06)

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K.S.R. COLLEGE OF ENGINEERING, TIRUCHENGODE – 637 215

(AUTONOMOUS)

B. E. / B.Tech. DEGREE END SEMESTER EXAMINATION, NOV / DEC - 2021

Third Semester

B.E. – AUTOMOBILE ENGINEERING

16AU315 / 20AU312 – Fluid Mechanics and Hydraulic Machines

(Regulations 2016 / 2020)

Time: Three hours **Maximum Marks: 100**

Answer ALL Questions

PART A — (10 x 2 = 20 Marks)

1. Define specific volume and specific weight.

2. Outline the concept of control volume with an example.

3. Define boundary layer thickness.

4. List out the minor losses in fluid flow pipe.

5. Is all the equations are dimensionally homogeneity. Justify your answer.

6. List out the applications of dimensionless parameters.

7. Infer axial, radial and mixed flow turbines.

8. What is the purpose of draft tube?

9. What will happen, if the suction head is more than the delivery head?

10. Compare reciprocating and rotary pump.

PART B — (5 x 16 = 80 Marks)

11. (a) Two large plane surfaces are 3cm apart. The space between the surfaces is filled with glycerine. What force is required to drag a very thin plate of surface area $0.6m^2$ between the two large plane surfaces at a speed of 0.6m/sec and its weight 20N? If (16)

   (i) The thin plate is in the middle of the two plane surfaces

   (ii) The thin plate is at a distance of 1.2cm from one of the plane surface.

   (iii) Take the dynamic viscosity of glycerine = $0.810 N\text{-}s/m^2$.

(OR)

(b) A pipe of 30cm diameter conveying $0.30m^3/s$ of water has a right angled bend in a horizontal plane. Find the resultant force exerted on the bend if the pressure at inlet and outlet of the bend are $24.5N/cm^2$ and $23.5N/cm^2$. (16)

12. (a) Derive Hagen- Poiseuille equation and state the assumption required. (16)

(OR)

(b) A pipe line, 30cm in diameter and 3200m long is used to pump up 50kg/s of an oil whose density is $950kg/m^3$ and whose kinematic viscosity is 2.1stokes. The centre of the pipe line at the upper end is 40m above than that at the lower end. The discharge at the upper end is atmospheric. Find the pressure at the lower end and draw the hydraulic gradient and the total energy line. (16)

13. (a) Derive on the basis of dimensional analysis suitable parameters to present the thrust developed by a propeller. Assume that the thrust P depends upon the angular velocity ω, speed of advance V, diameter D, dynamic viscosity μ, mass density ρ, elasticity of the fluid medium which can be denoted by the speed of sound in the medium C. (16)

(OR)

(b) A spillway model is to be built to a geometrically similar scale of 1/40 across a flume of 50cm width. The prototype is 20m high and maximum head on it is expected to be 2m. (16)

   (i) What height and what head on the model should be used?

   (ii) If the flow over the model at a particular head is 10lit/sec, what flow per meter length of the prototype is expected? If the negative pressure in the model is 15cm, what is the negative pressure in the prototype? Is it practicable?

14. (a) Obtain an expression for the work done per second by water on the runner of a Pelton wheel. Hence derive an expression for maximum efficiency of the Pelton wheel giving the relationship between the speed and bucket speed. (16)

(OR)

(b) A reaction turbine works at 450rpm under a head of 120m. Its diameter at inlet is 120cm and the flow area is $0.4m^2$. The angles made by absolute and relative velocity at inlet are 20^o and 60^o respectively, with the tangential velocity. Determine, the volume flow rate, the power developed and hydraulic efficiency. Assume velocity of whirl at outlet is zero. (16)

15. (a) Draw and explain the main parts of a centrifugal pump and derive the work done by the centrifugal pump on water. (16)

(OR)

(b) Find the maximum speed of a single acting reciprocating pump to avoid separation, which occurs at 3m of water (abs.). The pump has a cylinder of diameter 10cm and a stroke length of 20cm. The pump draws water from a sump and delivers to a tank. The water level in the sump is 3.5m below axis and in the tank the water level is 13m above the pump axis. The diameter and length of the suction pipe are 4cm and 5m while of delivery pipe the diameter and length are 3cm & 20m respectively. Take atmospheric pressure head is 10.3m of water. (16)

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