

MODULE 1

Chapter '	1:	Impact	of Jets	ŝ
-----------	----	--------	---------	---

1-1 to 1-41

Impulse momentum principle, Jet striking flat plates, stationary and moving vertical, inclined plates, hinged plates, curved vanes, series of plates and vanes mounted on wheel, concept of velocity triangles.

1.1	Introduction1-1
1.2	Impulse - Momentum Principle1-1
1.3	Force due to Impact of Jet on a Flat Fixed Plate1-2
1.3.1	When the Fixed Plate is Normal to Jet1-2
1.3.2	When Fixed Plate is Inclined at an Angle $\boldsymbol{\theta}$ with Jet1-2
1.4	Force Exerted by a Jet on Stationary Curved Plate or a Vane1-3
1.4.1	When Jet Strikes at the Centre of a Symmetrical Curved Plate1-3
1.4.2	When Jet Strikes an Unsymmetrical Curved Plate at One End Tangentially1-4
1.4.3	For Semicircular Curved Vane or Plate1-4
1.5	Force Exerted by a Jet on a Hinged Plate1-7
1.5.1	When the Plate is Held Vertical by External Force1-7
1.5.2	Angle Turned by Plate when Holding Force 'P' is not Applied1-7
1.6	Force Exerted by Jet on Moving Plates 1-11
1.6.1	Force on Moving Flat Plate in Direction of Jet 1-11
1.6.2	Force on Moving Inclined Plate in the Direction of Jet1-12
1.6.3	Impact of Jet on a Series of Flat Moving Plate 1-13
1.7	Impact of Jet on Moving Curved Vanes 1-16
1.7.1	Curved Vane Moving in the Direction of Jet1-16
1.7.2	Impact of Jet in case of Series of Moving Vanes in Direction of Jet1-17
1.7.3	Impact of Jet on Unsymmetrical Moving Curved Vane When Jet Strikes on One Tip of Vane Tangentially and Leaves at the other1-18
1.7.4	Force Exerted on a Series of Moving Radial Curved Vanes1-20
1.8	Jet Propulsion of Ships1-34

1.8.1	Jet Propulsion of Ship when Inlet
	Orifices are at Right Angles to the
	Direction of Motion of the Ship1-34
1.8.2	Jet Propulsion when the Inlet Orifice
	facing the Direction of Motion of Ship1-35

MODULE 2

Chapter 2: Hydraulic Turbines

2-1 to 2-79

General layout of hydro-electric plant, heads, efficiencies of turbine, classification, concept of velocity triangles working of Impulse Turbine (Pelton Wheel), Reaction Turbine, Francis Turbine, Kaplan Turbine, draft tube theory, specific speed, unit quantities, Characteristic curves, Cavitation.

2.1	Introduction2-1
2.1.1	Basic Classification of Hydraulic Turbines2-1
2.2	General Layout of a Hydro- Electric Power Plant2-2
2.3	Pelton Wheel or Pelton Turbine2-3
2.3.1	Construction and Working of Pelton Wheel2-3
2.4	Workdone and Efficiency of Pelton Wheel 2-5
2.5	Design Aspects and Important Points to Remember for Pelton Wheel2-8
2.5.1	Number of Buckets, Z on the Periphery of Pelton Wheel2-8
2.6	Introduction to Reaction Turbines2-23
2.7	Classification of Reaction Turbines2-24
2.8	Constructional Features of Reaction Turbines2-25
2.9	Comparison between Impulse Turbine and Reaction Turbine2-26
2.10	General Layout of a Reaction Turbine Plant2-27
2.11	Calculation of Work, Power and Efficiencies of Inward Radial Reaction Turbines2-28
2.11.1	Working Proportions of a Radial Flow Reaction Turbine2-29
2.12	Outward Radial Flow Reaction Turbines2-30



	•	
7	⇉	7
7	3	7

2.13	Comparison between Inward and Outward Radial Flow Reaction Turbines2-30
2.14	Francis Reaction Turbine2-31
2.14.1	Axial Flow Reaction Turbines - Propeller and Kaplan Turbines2-31
2.15	Draft Tube2-33
2.16	Draft Tube Theory2-49
2.16.1	Explanation of Draft Tube Theory2-49
2.16.2	To Show that Net Head Available on Turbine Remains Constant Irrespective of Location of Turbine w.r.t Tail Race Level2-50
2.16.3	Types of Draft Tubes2-51
2.17	Introduction to Governing of Turbine2-57
2.18	Governor and it's Functions2-57
2.19	Governing System for Turbines of a Hydro-Electric Power Plant2-58
2.20	Governing Mechanism2-58
2.21	Governing of Pelton Turbine2-59
2.21.1	Double Regulation Speed in Pelton Turbine 2-60
2.22	Governing Mechanism of a Francis Turbine 2-61
2.23	Governing Mechanism for Kaplan Turbine $2-62$
2.24	Performance of Water Turbines2-62
2.24.1	Introduction2-62
2.24.2	Standard Characteristics Curves2-62
2.24.3	Unit Quantities2-63
2.24.4	Main Characteristics2-64
2.24.5	Operating Characteristics (Constant Speed Characteristics)2-66
2.24.6	ISO-Efficiency Curves2-67
2.25	Specific Speed (N $_{\rm S}$) and Shape of Runner 2-68
2.25.1	Derivation of Specific Speed2-68
4.25.2	Shape of Runners2-68
2.25.3	Specific Speed for Pelton Wheel2-69
2.25.4	Specific Speed of Francis Turbine2-70

2.25.5 Specific Speed of Kaplan Turbine	2-70
2.26 Classification and Selection of Turbine	2-70
2.26.1 Sizes of Hydraulic Turbines	2-71
2.27 Cavitation in Reaction Turbines	2-74
2.27.1 Effects of Cavitation	2-74
2.27.2 Methods of Preventing Cavitation	2-75
2.27.3 Recent Development to Prevent Cavitation	2-75
2.27.4 Thoma's Cavitation Factor for Turbines	2-75

Chapter 3 : Centrifugal Pumps

3-1 to 3-49

Work done, heads, efficiencies, Minimum speed : series parallel operation, Multistage pumps, concept of velocity triangles, specific speed, model testing, priming, characteristic curves, NPSH, cavitation.

MODULE 3

	• •
3.1	Introduction 3-1
3.2	Classification of Pumps3-1
3.2.1	Difference between Centrifugal Pump and Inward Flow Hydraulic Turbine3-2
3.2.2	Pump Applications3-2
3.2.3	Advantages of Centrifugal Pumps over Reciprocating Pumps
3.3	Components of a Centrifugal
	Pump (C.F. Pump)3-2
3.3.1	Working of Centrifugal Pump3-3
3.4	Classification of Centrifugal Pumps3-4
3.5	Workdone by Impeller on Water3-8
3.6	Various Heads and Efficiencies of
	a Centrifugal Pump3-9
3.6.1	Relation between Manometer Head and Workdone by Impeller on Liquid3-10
3.6.2	Virtual Head, H _{virtual} 3-10
3.6.3	Manometric Head in terms of Suction and Delivery Pressure Measured by Pressure Gauge3-11
3.7	Losses and Efficiencies3-11
3.7.1	Losses in Pumps3-11
3.7.2	Efficiencies of a Centrifugal Pump3-12



_	g.	٠.	
٠,	٩	e.	

3.8	Effect of Vane Discharge Angle φ on Manometric Efficiency3-13
3.9	Minimum Starting Speed of Pump3-14
3.9.1	$\label{eq:minimum Diameter of Impeller, D13-14} Minimum Diameter of Impeller, D13-14$
3.10	Performance Characteristics of a Centrifugal Pump3-28
3.10.1	Test Set Up for Conduct of Tests on Centrifugal Pump in a Laboratory3-28
3.10.2	Types of Performance Characteristic Curves 3-29
3.10.2.1	Main Characteristic Curves3-29
3.10.2.2	Operating Characteristic Curves3-30
3.10.2.3	ISO-efficiency or Maschel Curves3-30
3.10.2.4	Constant Head and Constant Discharge Curves
3.11	Cavitation in Centrifugal Pumps3-31
3.11.1	Estimation of Maximum Permissible Suction Lift (Limited by Cavitation)3-31
3.11.2	Net Positive Suction Head (NPSH)3-32
3.11.3	NPSH (Required)3-32
3.11.4	NPSH (Available)3-32
3.11.5	Thoma's Cavitation Factor3-32
3.12	Priming of a Centrifugal Pump 3-33
3.13	Trouble Shooting of Centrifugal Pumps and their Remedies
3.14	Multistage Centrifugal Pumps3-34
3.14.1	Multistage Centrifugal Pumps for High Heads
3.14.2	Multistage Centrifugal Pumps for High Discharge3-35
3.14.3	Comparison between Single Stage and Multistage Pumps3-35
3.15	Model Relationships3-40
3.15.1	Head Coefficient, $K_{\hbox{\scriptsize H}}$
3.15.2	Discharge Coefficient, $K_{\ensuremath{\mathbf{Q}}}$
3.15.3	Power Coefficient, K_p 3-41
3.15.4	Specific Speed, $\mathbf{N_s}$ based on Discharge
	and Power as Applied to Centrifugal Pumps 3-41
3.16	Scale Effect3-42

3.17	Moody's and Other Relationship
	Considering the Scale Effect3-42

MODULE 4

Chapter 4: Miscellaneous Hydraulic Machinery

4-1 to 4-21

Hydraulic Ram, Press, Accumulator, Intensifier, Crane and Lift.

4.1	Introduction	4-1
4.2	Hydraulic Accumulator	4-1
4.3	Accumulator Types	4-1
4.3.1	Dead Weight of Gravity Type Simple Accumulator	4-1
4.3.2	Differential Accumulator	4-2
4.4	Hydraulic Intensifier	4-3
4.5	Hydraulic Press	4-7
4.5.1	Constructional Features of Hydraulic Press	4-8
4.6	Hydraulic Crane	4-11
4.7	Hydraulic Lift	4-12
4.7.1	Hydraulic Jack	4-13
4.8	Hydraulic Ram	4-15

MODULE 5

Chapter 5: Uniform Flow Through Open Channels 5-1 to 5-48

Uniform Flow: Flow through open channel: Definition, types of channels, Prismatic, non-prismatic channels, Types of flows in channels, Uniform flow: steady flow and unsteady flow, laminar and turbulent flow, subcritical flow, supercritical flow, Chezy's formula, Manning's formula, hydraulically efficient channel cross-sections (most economical sections).

5.1	Introduction to Open Channel Flow 5-1
5.1.1	Introduction5-1
5.1.2	Comparison between Open Channel Flow and Pipe Flow5-2
5.1.3	Classification of Channels5-3
5.1.4	Classification of Flows5-3



6.1

Specific Energy and Critical Flow 6-1

5.1.5	Channel Geometry and Geometric Elements of Channel Sections5-6
5.1.6	Velocity Distribution in a Channel Section5-7
5.1.7	One-Dimensional Approach of Flow Analysis5-8
5.1.8	Pressure Distribution in a Channel Section5-9
5.1.9	Equation of Continuity5-10
5.1.10	Energy Equation5-10
5.1.11	Solved Examples 5-11
5.2	Uniform Flow 5-14
5.2.1	Introduction5-14
5.2.2	Establishment of Uniform Flow5-15
5.2.3	Uniform Flow Formulae5-15
5.2.4	Chezy's Formula5-15
5.2.5	Darcy-Weisbach Friction Factor,f5-17
5.2.6	Manning's Formula5-18
5.2.7	Manning's Roughness Coefficient, n5-18
5.2.8	$Computation \ of \ Uniform \ Flow 5-20$
5.2.9	Computation of Normal Depth5-22
5.2.10	Second Hydraulic Exponent, N 5-25
5.2.11	Maximum Discharge and velocity of a
	Channel of Second Kind 5-26
5.2.12	Hydraulically Efficient Channel Sections 5-28
5.2.13	Solved Examples 5-31
5.3	Problems 5-46

MODULE 6

Chapter 6: Non Uniform Flow Through Open Channels 6-1 to 6-52

Concept of specific energy and specific energy curve, Dimensionless specific energy discharge curve, applications of specific energy and Momentum principle to open channel flow, specific force. Gradually varied flow, equation for gradually varied flow, back water curve and afflux, Introduction to surface profiles, Hydraulic jump and standing wave.

6.1.1	Specific Energy6-1
6.1.2	Specific Energy Curve and Critical Flow6-1
6.1.3	Depth-Discharge Diagram6-4
6.1.4	Dimensionless specific energy
	and discharge curves6-5
6.1.5	The Section Factor for Critical Flow
	Computation
6.1.6	First Hydraulic Exponent, M6-6
6.1.7	Critical Flow and its Computation 6-6
6.1.8	Solved Examples6-10
6.2	Gradually Varied Flow6-18
6.2.1	Introduction6-18
6.2.2	Differential Equation of GVF
	and its Various Forms6-19
6.2.3	Classification of Channels and Flow Profiles6-23
6.2.4	Practical Examples of Occurrence of GVF Profiles6-26
6.2.5	Control Sections6-27
6.2.6	Analysis of Flow Profiles6-28
6.2.7	Introduction to Methods of Computation6-31
6.2.7.1	Direct Step Method6-32
6.2.8	Solved Examples 6-33
6.3	Rapidly Varied Flow - Hydraulic Jump6-37
6.3.1	Introduction6-37
6.3.2	Momentum Equation and specific force6-37
6.3.3	Hydraulic Jump6-39
6.3.3.1	Introduction6-39
6.3.3.2	Applications of Hydraulic Jump6-40
6.3.3.3	Equations of Hydraulic Jump
0.5.5.5	for Prismatic Channel6-40
6.3.3.4	Classification of Hydraulic Jump6-42
6.3.3.5	Characteristics of Hydraulic
	Jump in Rectangular Channel6-43
6.3.3.6	Use of Jump as an Energy Dissipater6-44
6.3.4	Solved Examples6-45
6.4	Problems6-50

