**5. FLUID DYNAMICS**

**BERNOULLI’S EQUATION:**

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| Forces acting on the fluid element shown in the figure,   |  |  | | --- | --- | | Gravitational Force | Pressure Force | | Viscous Force | Turbulent Force | | Surface Tension Force | Compressible Force | | |  | |
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| Bernoulli’s Eq. For Steady and incompressible Flow, | | |  |

* Net mechanical energy of fluid in an ideal flow remains constant.

**VARIOUS FORMS OF BERNOULLI’S EQUATION:**

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| **Energy Per unit mass,** | | | **Energy Per unit Volume,** | |
| Static Pressure | | Dynamic Pressure (Rise in pressure due to drop in K.E.) | | Hydrostatic Pressure (Rise in pressure due to drop in P.E.) |
| **Energy Per unit weight,** | At stagnation point, Stagnation Pressure = Static Pressure + Dynamic Pressure  Piezometric Pressure = Static Pressure + Hydrostatic Pressure | | | |

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| **LIMITATIONS/ ASSUMPTIONS IN BERNOULLI’S EQUATION** | |
| 1. Flow is Steady. 2. Incompressible Flow. 3. Heat Transfer effects are neglected. 4. In Irrotational Flow, B. Eq. is valid across any two stream line but for Rotational flow, B. Eq. is valid only along stream line not across the stream line. | 1. Involvement of shaft work (Pump & Turbine): Heads need to balance when energy per unit mass is added or removed. E.g. Pump is adding head & turbine is Using head to gain shaft work. 2. Valid only for ideal flow. But by introducing head loss, we can use the B. Eq. for real flow. |

**HEAD LOSS:** Energy given by the fluid to overcome resistance against the flow per unit weight is called head loss.

**NOTE:** In the absence of a pump, Real flow takes place from higher total head to lower total head.

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| **KINETIC ENERGY CORRECTION FACTOR ():**  When the velocity profile is non uniform, Total velocity head and avg. velocity head are not equal.  Local Velocity = & Avg. Velocity =   |  |  |  | | --- | --- | --- | |  |  |  | | Always  For uniform Flow | For Laminar Flow through pipe | For turbulent flow through pipes, | |  |

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| **DIFFERENCE IN PIEZOMETRIC HEAD:**   |  |  | | --- | --- | |  |  | | The figure shows a pipe of uniform cross section inclined in a vertical  plane. A U-tube manometer - Sarthaks eConnect | Largest Online Education  Community |

**EQUATION OF POWER:**

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| **FREE LIQUID JET:**   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  |  | | Max. Height | | Time of Flight | |  | |  | |  | |   From above both equations, | | Free Jet Liquid Assignment Help| Homework Help| Online Live Fluid Mechanics  Tutoring Help | |
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| **VELOCITY MEASUREMENT** |  |

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| 1. **PITOT TUBE + PIEZOMETER:**  |  |  |  | | --- | --- | --- | |  |  |  |   From above equations, we can find velocity head or velocity in the pipe.  It can’t use for gaseous fluid. | What Is Pitot tube? Construction, Working Principle of Pitot tube | Mecholic |

**NOTE:** If is not give, .

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| 1. **PITOT-STATIC TUBE:**   From the previous derivations, |  |

**DISCHARGE/ FLOW MEASUREMENT:**

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| **OBSTRUCTION FLOWMETER:** E.g. Orifice Meter, Venturi Meter, Nozzle Meter. | |
| **Head-loss in Obstruction Flowmeter:**  From the mass conservation in incompressible flow,   |  |  | | --- | --- | |  |  | | Venturi Meters - Pipes - Fluid Mechanics - Engineering Reference with  Worked Examples |
| **VENTURI METER:**   |  |  | | --- | --- | |  |  |   By Considering |  |

equation is same for all measuring device.

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In Venturi Meter, To Reduce Minor Losses in Diffuser, Converging Angle Divergence Angle

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|  | Venturi Meter | Nozzle Meter | Orifice Meter |
|  | 0.95-0.98 (High) | 0.85 (Medium) | 0.65 (Low) |
|  | Low | Medium | High |
| Accuracy | High | Medium | Low |
| Cost | High | Medium | Low |

**VORTEX MOTION:** It’s motion of fluid along a curved path is known as vortex motion.

E.g. Whirlpool, Tornado, Water Sink, etc…

1. exists.
2. Stream Lines are curved.

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| **TYPE OF VORTEX FLOW** | |
| **FREE VORTEX FLOW** | **FORCED VORTEX FLOW** |
| It’s naturally (By the virtue of motion itself) exists. | Appling external torque for generating Vortex flow. |
| External Torque is equal to zero. | Constant External Torque is applied. |
|  | Angular Velocity of every partial is same. |
| Singularity Point: |  |
| Flow is irrotational. E.g. Bernoulli’s equation can be applied between any point. | Flow is rotational. E.g. Bernoulli’s equation can be applied between any point lying on same stream lines. |
| Valid for any 2 random points, | Valid for any 2 random points, |

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| **RANKINE VORTEX MOTION:** Vortex Motion having a combination of free vortex & forced vortex.  Rankine Vortex - an overview | ScienceDirect Topics |

**EQUATION OF PRESSURE:**

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| |  |  | | --- | --- | |  |  |   From the figure,   |  |  | | --- | --- | |  |  | | Equation Of Motion For Vortex Flow Assignment Help Homework Help Online  Live Tutoring Help |

**Note:** Forced Vortex Flow is Part of Rigid Body Motion.

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| **FREE VORTEX FLOW** | **FORCED VORTEX FLOW** |
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| Hence, the flow is irrotational. | Hence, the flow is rotational. |

**EQUATIONS OF ISOBAR:** Constant pressure imaginary curve in vortex (Forced) flow.

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**VOLUME OF PARABOLOID:** Volume of revolution of parabola. E.g. Circumscribing cylinder with parabola.

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| **Circumscribed** refers to a shape surrounding another shape. |  |