



# FLUID FLOW OPERATIONS

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**INTENDED AUDIENCE :** Chemical Engineering, Civil Engineering and Mechanical Engineering UG and PG students and Faculty

**INDUSTRY SUPPORT :** Chemical Industries, Flow reactor handling, Piping system, Metering fluent etc.

### ABOUT COURSE :

This course is structured as a MOOCS course for students or junior engineers studying chemical, mechanical or civil engineering. In this course, effort will be made to introduce students / engineers to fluid mechanics by making explanations easy to understand, including recent information and comparing the theories with actual phenomena. The following features will be included in the course

1. Many illustrations, photographs and items of interest will be presented for easy understanding.
2. Assignments and exercises will be given at the ends of course lecture to test understanding of the chapter topic.
3. Special emphasis will be given on real multiphase flow phenomena with specific applications

### ABOUT INSTRUCTOR :

Prof. Subrata Kumar Majumder is a Professor in the Chemical Engineering Department, IIT Guwahati, India. His research interests include multiphase flow and reactor development, hydrodynamics in multiphase flow, mineral processing, process intensifications and micro-nano bubble science and technology and its applications. He is a Fellow of the International Society for Research and Development, 8A Kapteinsvigein, London, UK. He is also a recipient of various honours and awards like: Editor, Journal of Chemical Engineering Research Studies, Guest editor, American Journal of Fluid Dynamics, published by Scientific & Academic Publishing Co., CA, 91731, USA, Editorial board member of Scientific Journal of Materials Science, IIME Award on beneficitation from Indian Institute of Mineral Engineers (IIME), Editorial board Member of the Journal of Science and Technology, Scientific and Academic Publishing, USA, Advisory board member of Excelling Tech Publishers (ETP), London, UK. He is a life member of Indian Institute of Chemical Engineers, Indian Institute of Mineral Engineers, member of Institute of Engineers (India), Member of Asia-Pacific Chemical, Biological & Environmental Engineering Society (PCBEE), senior member of International Association of Engineers (IAE), Japan. He authored four books, five book chapters, and has more than 80 publications in several reputed international journals. Presently he is working in the field of Microbubble science and technology and its applications in mineral beneficiation, food processing and arsenic, ammonia and dye removal and process intensifications by developing ejector-induced gas aided extraction process.

### COURSE PLAN :

**Week 1 :** Characteristics of a fluid: Fluid: Units and dimensions; Density, specific gravity and specific volume; Viscosity; Surface tension; Compressibility; Characteristics of a perfect gas

**Week 2 :** Fluid statics: Pressure: Forces acting on the vessel of liquid: Why does an object float?; Relatively stationary state

**Week 3** : Fundamentals of flow: Streamline and stream tube; Steady flow and unsteady flow; Three-dimensional, two-dimensional and one-dimensional flow; Laminar flow and turbulent flow; Reynolds number; Incompressible and compressible fluids; Rotation and spinning of a liquid; Circulation.

**Week 4** : One-dimensional flow: mechanism for conservation of flow properties; Continuity equation; Conservation of energy; Conservation of momentum; Conservation of angular momentum

**Week 5** : Flow of viscous fluid: Continuity equation; Navier-Stokes equation; Boundary layer; Velocity distribution of laminar flow; Velocity distribution of turbulent flow; Theory of lubrication

**Week 6** : Losses in pipes: Loss by pipe friction; Frictional loss on pipes other than circular pipes; Various losses in pipe lines; Flow in the inlet region; Pumping to higher levels

**Week 7** : Flow in a water channel: Flow in an open channel with constant section and flow velocity; Best section shape of an open channel; Specific energy; Constant discharge; Constant specific energy; Constant water depth; Hydraulic jump

**Week 8** : Drag and lift and cavitation: Flows around a body; Forces acting on a body; The drag of a body; The lift of a body; Cavitation

**Week 9** : Dimensional analysis and law of similarity: Dimensional analysis; Rayleigh's method, Buckingham's Pi theorem; Application examples of dimensional analysis; Law of similarity

**Week 10** : Compressible fluid flow: Introduction, Thermodynamic characteristics, Speed of sound or sonic velocity, Mach number, Basic Equations of One dimensional, compressible flow, Isentropic compressible Flow, Shock Waves, Expansion waves, Fanno and Rayleigh Flow

**Week 11** : Measurement of flow: Measurement of flow velocity; Measurement of flow discharge

**Week 12** : Multiphase flow phenomena and its application: Introduction of multiphase flow patterns; Flow patterns map; Hydrodynamics in multiphase flow, Application of multiphase flow