Fluid Mechanics Equations

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Bernouilli's Equation

$$\frac{1}{2}\rho v^2 + \rho g z + p = constant$$

In a streamline, flow must be inviscid, incompressible, and steady

In a general region, flow must be inviscid, incompressible, steady, and irrotational

Channel flow:

$$\frac{dp}{dx} = \mu \frac{d^2 u}{dy^2}$$

Flow is in x direction

Flow must be steady, and fluid must be incompressible and irrotational

Continuity Equation

$$\frac{\partial \rho}{\partial t} = -\nabla \cdot (\rho \boldsymbol{v})$$

Fluid can be compressible - valid for a general flow

Euler Equation

$$\rho \frac{\partial \boldsymbol{v}}{\partial t} + \rho\ \boldsymbol{v} \cdot \nabla \boldsymbol{v} = -\nabla p$$

Inviscid flow - $Re \to \infty$ (Reynolds number)

Vorticity:

$$\boldsymbol{\omega} = \nabla \times \boldsymbol{v}$$

Irrotational:

An inviscid fluid that has no rotation will stay irrotational

Navier-Stokes equation:

$$\rho \frac{\partial \boldsymbol{v}}{\partial t} + \rho \boldsymbol{v} \cdot \nabla \boldsymbol{v} = -\nabla p + \mu \nabla^2 \boldsymbol{v} + \boldsymbol{F}$$