

EQUATIONS FOR BASIC HYDRAULIC PRINCIPLES

Lesson 1: Fluid Properties

Force = Mass (M) times acceleration (a) (Newton's Law)

or

Weight (pounds) = mass (slugs) times gravity (g in ft/sec^2),

where acceleration, $g = 32.2 \text{ ft}/\text{sec}^2$

Density (ρ) = Mass of fluid/unit volume, where $\rho_{\text{water}} = 1.94 \text{ slugs}/\text{ft}^3$

Unit weight (γ) = weight of fluid/unit volume = ρg

where $\gamma_{\text{water}} = 62.4 \text{ pounds}/\text{ft}^3$

Dynamic viscosity of fluid (μ , in $\frac{\text{sec lb}}{\text{ft}^2}$ or $\frac{\text{slug}}{\text{sec ft}}$) is defined by $\tau = \mu \frac{\partial v}{\partial y}$, where τ is the shearing stress in lbs/ft^2 , and the right-hand term is the rate of change of velocity in the fluid.

Kinematic viscosity (ν , in ft^2/sec) = μ/ρ

Pressure (P) = unit weight of water (γ_{water}) times depth (y),

which says pressure increases linearly with depth.

Lesson 2: Forces on Submerged Objects

Force on a vertical rectangular gate:

$$F = \frac{\gamma W D^2}{2}, \text{ where } D = \text{depth, } W = \text{width (triangular pressure prism)}$$

Force is always equal to volume of pressure prism, and acts through the centroid of the pressure prism. Force is also equal to the pressure at the centroid of the gate area times the area of the gate.

To calculate centroid of a complex shape:

$$F_R \cdot y_R = \Sigma(F \cdot y) \text{ or } y_R = \frac{\Sigma(F \cdot y)}{F_R}, \text{ where } F_R \text{ is the resultant force}$$

Lesson 3: Similitude and Dimensional Analysis

Reynolds Number, $Re = V\rho/\mu$ (Velocity, length, density/viscosity)

Froude Number, $Fr = \frac{V}{\sqrt{gD}}$ where V = velocity, D = depth, g = gravity, $32.2 \text{ ft}/\text{sec}^2$

Equations For Basic Hydraulic Principles

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