A Review of Fluid Mechanics for Earth 458 Students

Table 1: List of Constants, all values are for water at 15.6 °C

Parameter	**Symbol**	**Typical Value for Water**
Gravitational Acceleration	g	9.81 (m/s^2)
Density	ρ	999 (kg/m^3)
Specific Weight	γ	9.8 (kN/m^3)
Dynamic Viscosity	μ	1.12 E-3 (Ns/m^2)
Kinematic Viscosity	ν	1.12 E-6 (m^2/s)

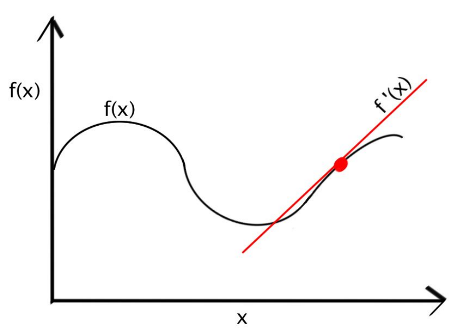
Table 2: List of Variables

Parameter	**Symbol**	**Unit**
Hydraulic Head	h or h$_T$	(m)
Pressure Head	Ψ or h$_p$ or P	(m)
Elevation Head	z or h$_z$	(m)
Velocity Head	h$_v$	(m)
Volume	V	(m^3)
Flow	Q	(m^3/s)
Velocity	v	(m/s)

1 Calculus

Derivative:
A derivative is the rate of change of the dependent variable with respect to rate of change of the independent variable (the slope of the line tangent to the curve). Such that:

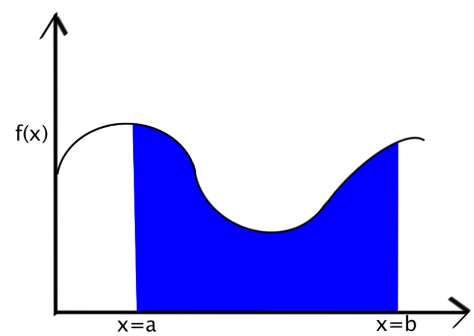
$$f'(x) = \frac{\Delta f(x)}{\Delta x} \tag{1}$$



Integral:
Integral is the "area below the curve." Such that:

$$\text{area} = \int_a^b f(x)dx \tag{2}$$

where a is lower bounds and b is the upper bounds. The blue region shown below is the "area below the curve" for the definite integral.



2 Hydrostatics

Pressure:

$$P = \rho\ g\ h \tag{3}$$

where:

$$\gamma = \rho g \tag{4}$$

so that:

$$P = \gamma\ h \tag{5}$$

Elevation:

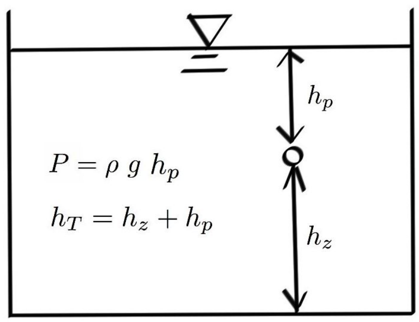
$$h_z = z \tag{6}$$

Hydraulic Head:

$$h = h_z + \frac{P}{\gamma} \tag{7}$$

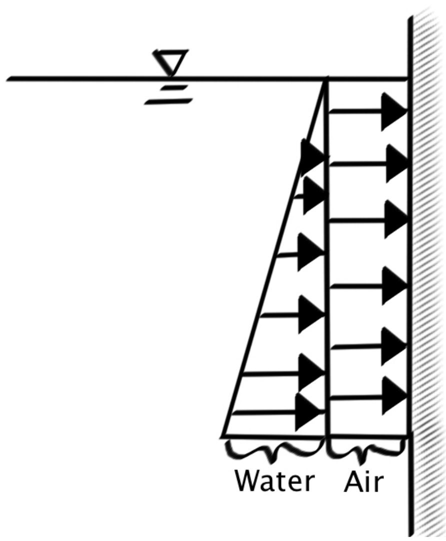
or

$$h_T = h_z + h_p \tag{8}$$



Pressure Forces:

$$F = \gamma \frac{h}{2} A + P_{atm} A \tag{9}$$



Buoyancy Forces:

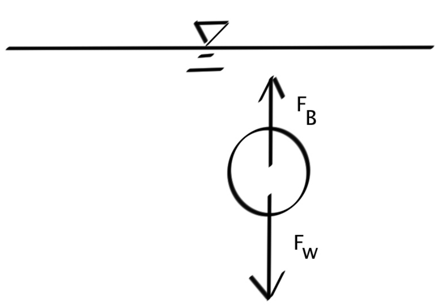
$$F_B = \gamma_{water} V \tag{10}$$

Weight of Object:

$$F_W = \gamma_{object} V \tag{11}$$

Sum of Forces:

$$\Sigma F = F_B - F_W \tag{12}$$



3 Fluid Dynamics

Bernoulli Equation:

$$h = \frac{P}{\gamma} + \frac{v^2}{2g} + z \tag{13}$$

and

$$\frac{P_1}{\gamma} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{v_2^2}{2g} + z_2 \tag{14}$$

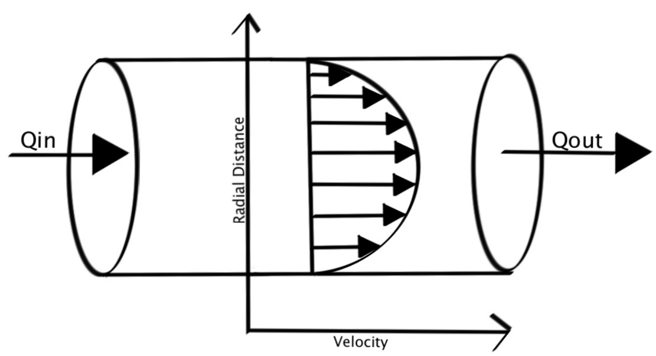
or

$$h_T = h_P + h_v + h_z \tag{15}$$

Scaling:
For groundwater flow the velocity head, h_v, is much smaller than the pressure head or elevation head. Such that:

$$h_v \ll h_z \ \ and \ \ h_v \ll h_P \tag{16}$$

No Slip Condition:
Fluid velocity approaches zero next to solid boundaries. In pipe flow, the maximum velocity occurs at the center of the pipe.



Continuity:
Flow in = Flow out
For an incompressible ideal fluid:

$$Q_1 = A_1 \bar{V}_1 = Q_2 = A_2 \bar{V}_2 \tag{17}$$