MIDTERM 1
Equation Sheet
MAE101B del Alamo section

Note: For simplicity, you are allowed to use $\pi = 3.14$, $g = 10\ m/s^2$ in the numerical calculations of this midterm.

Mass conservation equation

$Q = AV = const$

$A = \dfrac{\pi D^2}{4}$ *in a pipe*

(D = pipe diameter, V = average velocity)

Reynolds Numbers

Reynolds number based on the pipe diameter: $\mathrm{Re}_D = \dfrac{\rho V D}{\mu}$

Friction Reynolds number based on the roughness height $\mathrm{Re}_\varepsilon = \dfrac{\rho u_\tau \varepsilon}{\mu}$

(ρ = fluid density, μ = fluid viscosity, u_τ = friction velocity, ε = roughness height)

Energy Equation Between Two Arbitrary Sections 1 and 2

$$\frac{p_2 - p_1}{\rho g} + \left(\frac{V_2^2}{2g} - \frac{V_1^2}{2g}\right) + z_2 - z_1 = \frac{\dot{W}_{pump}}{\rho g Q} - \frac{\dot{W}_{turbine}}{\rho g Q} - h_f - h_m$$

(p = pressure, z = vertical coordinate, g = gravitational acceleration)

Friction head loss: $h_f = \dfrac{V^2}{2g}\dfrac{L}{D} f$

(*f* is the Darcy friction factor and L the pipe length)

Minor head losses: $h_m = \dfrac{V^2}{2g} K$

(K is the loss coefficient across the element that generates the friction losses, i.e. a reservoir exit)

Friction velocity: $\dfrac{u_\tau}{V} = \left(\dfrac{f}{8}\right)^{1/2}$

Laminar / Turbulent Regimes

$\mathrm{Re}_D < 2300$ laminar flow
$\mathrm{Re}_D > 2300$ turbulent flow

Hydrodynamically smooth / rough Regimes

$0 < \mathrm{Re}_\varepsilon < 5$ hydraulically smooth pipe
$5 < \mathrm{Re}_\varepsilon < 70$ hydraulically transitional pipe
$\mathrm{Re}_\varepsilon > 70$ hydraulically fully rough pipe

Moody Diagram