Fluid Mechanics

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Intro to fluids

- Knudsen Number: $\lambda = \frac{k_B T}{\sqrt{2}\pi d^2 P}$, $K_n = \frac{\lambda}{L}$, $K_n \leq 0.01$ for continuum
- Rate of Shearing Strain: $\dot{\gamma} = \frac{d\beta}{dt} = \frac{du}{dy}$
- Shearing Stress: $\tau = \mu\dot{\gamma}$ for Newtonian Fluids
- Kinematic Viscosity: $\nu = \frac{\mu}{\rho}$
- Reynold's Number: $\frac{\rho V D}{\mu}$
- Sutherland Equation (gases): $\mu = \frac{CT^{3/2}}{T+S}$
- Andrade Equation (liquids): $\mu = De^{\frac{B}{T}}$
- Bulk Modulus: $E_v = -\frac{dp}{dV/V} = \frac{dp}{d\rho/\rho}$, Compressibility: $\kappa = \frac{1}{E_v}$
- For polytropic process $\frac{P}{\rho^x}$ Bulk Modulus: $E_v = xP$
- Speed of Sound: $c = \sqrt{\frac{dp}{d\rho}} = \sqrt{\frac{E_v}{\rho}} = \sqrt{\gamma RT}$
- Excess Pressure: $p = \frac{2T}{R}$ for Soap: $p = \frac{4T}{R}$
- Height in a capillary: $h = \frac{2T\cos\theta}{\gamma R}$ (γ is specific wt.)

Fluid statics

- For the wedge: $P_y - P_s = \rho\frac{\delta y}{2}a_y$, $P_z - P_s = \rho\frac{\delta z}{2}(a_z + g)$
- Surface Force: $\delta F_s = -\nabla P(\delta x\delta y\delta z)$, Body Force: $\delta W = -\gamma(\delta x\delta y\delta z)\hat{k}$
- Using Newton's 2nd Law: $-\nabla P - \gamma\hat{k} = \rho\hat{a}$
- Incompressible fluids: $P_2 - P_1 = \rho gh$, For compressible fluids: $\frac{dp}{dz} = -\rho g = -\frac{pg}{RT}$
- Troposphere: $T = T_a - \beta z$
- Resultant force Centroid $\int ydA = y_c A$, Centre of pressure $y_R = \frac{\int y^2 dA}{y_c A}$
- Centre of pressures: $y_R = \frac{I_{xc}}{y_c A} + y_c$, $x_R = \frac{I_{xyc}}{y_c A} + x_c$
- Metacentric height: $GM = \frac{I_0}{V_{submerged}} - CG$
- Stability: $MG > 0$ $(stable)$; $MG < 0$ $(unstable)$

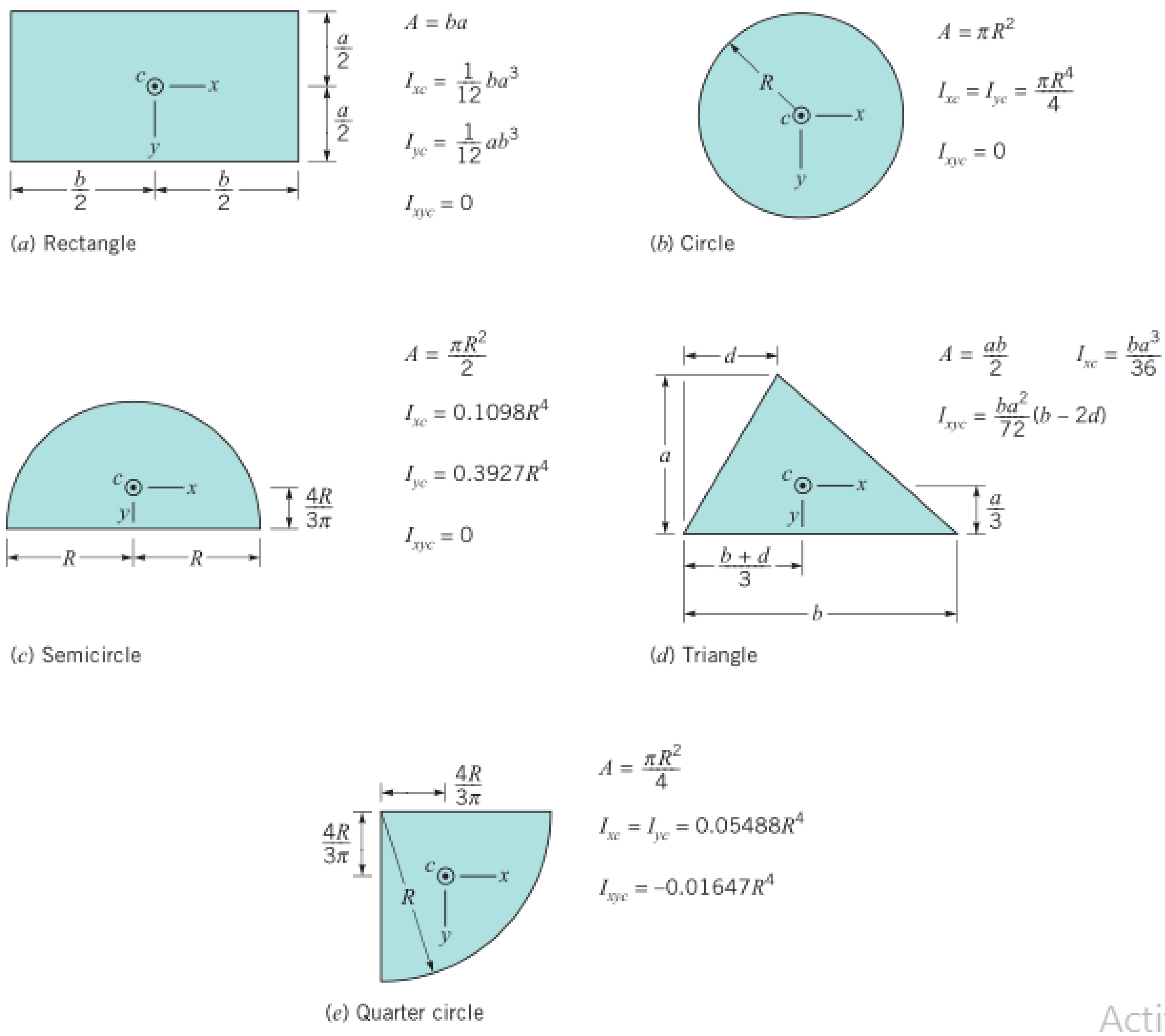

Figure 1: Moment of inertias for some systems