ME 4054: Estimation for Spring 2009

Estimation Techniques

Quick Models

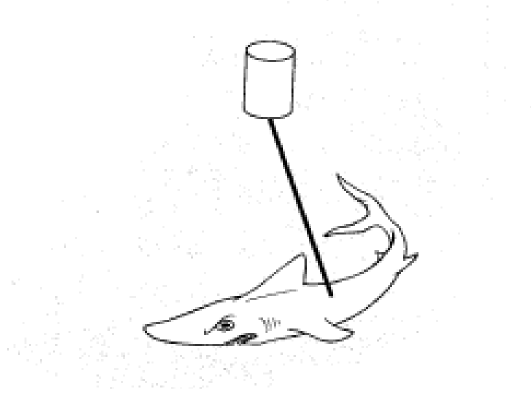
➡ Quick measurements

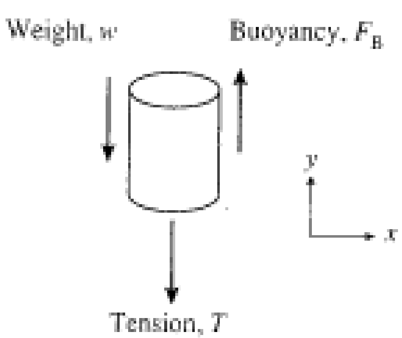
➡ Quick Calculations

Learn when to say that doesn’t sound right

Quick Models

- Rourke's Formulas for Stress and Strain
- Intro to Mechanical Engineering by Wickert





Tension = 400 lb

Weight	$w = \rho g V$
Buoyancy force	$F_B = \rho_{fluid} g V_{object}$
Reynolds number	$Re = \frac{\rho v l}{\mu}$
Pipe flow velocity	$v_{max} = \frac{d^2 \Delta p}{16 \mu L}$
	$v_{avg} = \frac{1}{2} v_{max}$
	$v = v_{max}\left(1 - \left(\frac{r}{R}\right)^2\right)$
Volumetric flow rate	$q = \frac{\Delta V}{\Delta t}$
	$q = A v_{avg}$
	$q = \frac{\pi d^4 \Delta p}{128 \mu L}$
	$A_1 v_1 = A_2 v_2$
Drag force	
General	$F_D = \frac{1}{2}\rho A v^2 C_D$
Special case: Sphere with $Re < 1$	$C_D = \frac{24}{Re}$
Lift force	$F_L = \frac{1}{2}\rho A v^2 C_L$
Bernoulli's equation	$\frac{p}{\rho} + \frac{v^2}{2} + gh = \text{constant}$

Quick Measurements

- Length: hair diameter =50 microns

  foot or floor tile = 1 ft

  = 100 m

- Density/ Viscosity

Know the density and viscosity of typical fluids (order of magnitude will suffice)

	Density, ρ		Viscosity, μ	
Fluid	kg/m^3	$slug/ft^3$	$kg/(m \cdot s)$	$slug/(ft \cdot s)$
Air	1.20	2.33×10^{-3}	1.8×10^{-5}	3.8×10^{-7}
Helium	0.182	3.53×10^{-4}	1.9×10^{-5}	4.1×10^{-7}
Freshwater	1000	1.94	1.0×10^{-3}	2.1×10^{-5}
Seawater	1026	1.99	1.2×10^{-3}	2.5×10^{-5}
Gasoline	680	1.32	2.9×10^{-4}	6.1×10^{-6}
SAE 30 oil	917	1.78	0.26	5.4×10^{-3}

Quick Measurements

- Elastic Modulii:

Material	Elastic Modulus, E		Poisson's Ratio, ν	Weight Density, ρ_w	
	Mpsi	GPa		lb/ft^3	kN/m^3
Aluminum alloys	10	72	0.32	172	27
Copper alloys	16	110	0.33	536	84
Steel alloys	30	207	0.30	483	76
Stainless steels	28	190	0.30	483	76
Titanium alloys	16	114	0.33	276	43

- Strength

Typical Quantities Engineers should know: Efficiency

IC engine	15-25%
Electric Motor	80%
Wind Turbine	30-50%
Solar Cell	5-15%
Hot Water heater	60-65%
Furnace	80-95%

What is the efficiency for typical energy producing systems?

Drag

Economy sedan at 60 mph	0.34
Sports Car at 60 mph	0.29
Suv at 60 mph	0.45
Racing bike rider	0.9
Person	1.2

Range from 0.3 to 1.2

Quick Calculations

- Round off, check units
- Example Reynolds number: $$Re = \frac{\rho v l}{\mu}$$

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0.3 in diameter bullet at 2400 ft/s
Water through a 1 cm pipe, 0.5 m/s
Submarine with full of 33ft, 15 knots

5000 **pipe** 6.7 E7 **Sub** 3.7 E5 **bullet**

Other Examples of Quick Calculations

Fluids Engineering

Shear stress	$\tau = \mu \frac{v}{h}$
Pressure	$p_1 = p_0 + \rho g h$
Weight	$w = \rho g V$
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Thermal and Energy Systems

Energy	
Gravitational potential	$U = mg\, \Delta h$
Elastic potential	$U = \frac{1}{2} k\, \Delta L^2$
Kinetic	$U = \frac{1}{2} m v^2$
Work of a force	$W = F\, \Delta d$
Average power	$P_{\text{avg}} = \frac{W}{\Delta t}$
Heating value	$Q = mH$
Specific heat	$Q = mc(T - T_0)$
Heat conduction	$Q = \frac{\kappa A \Delta t}{L}(T_h - T_l)$
Energy conversion/conservation	$Q = W + \Delta U$
Efficiency	
Real	$\eta = \frac{W}{Q_h}$
Ideal Carnot	$\eta_C = 1 - \frac{T_l}{T_h}$
Power plant	$\eta \approx \frac{W_t}{Q_{sg}}$

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