MECH 328

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The Art of Estimation

AGENDA

- Motivation
- Warm-up Exercises
- Estimation Relevant to the Trailrider

Motivation and Objectives

Q: Why do we estimate things?

A:

1. Simplify – give us insight
2. Throw out "bad" ideas
3. Full calculation takes too long

- The objective of today's presentation is to think about estimation generally, and then more specifically in the context of the Trailrider

What do Engineers Estimate?

1. Weight
2. Force
3. Size
4. Speed / Velocity
5. Power
6. Frequency
7. Temperature
8. Cost

Warm-up 1

Q: A paper clip is unfolded so it is straight, and one end is held in a vice, vertically. What is the maximum mass it can support from the free end?

A: $\sigma_{ultimate} = \frac{F}{A}$ $\quad A \approx 1mm^2 \sim 10^{-6} m^2$

$\sigma_{ultimate,steel} \approx 400 \times 10^6 \, N/m^2$

$F \approx 400 \, N \longrightarrow mass \sim 40 kg$.

Warm-up 2

Q: The Building Code defines the roof load (N/m^2) that a residential building must sustain. What do you estimate the requirement is in Vancouver?

A: Let's start by listing expected sources of load:

1. Precipitation (snow or ice).
2. Roofing Material
3. Wind load
4. Seismic.

Live Load.

Warm-up 2 (Cont'd)

Estimates:

1. Some depth of wet snow. say $d = 0.6\,m$, $\rho = 200\,kg/m^3$, $g \sim 10\,m/s^2$. $\Big\}$ $1000\,\frac{N}{m^2}$
2. $40\,kg/m^2 \rightarrow 400\,N/m^2$
3. $p \sim \frac{1}{2}\rho V^2 \sim 0.5 \cdot 40^2 \sim 800\,N/m^2$.
4. $\sim 400\,N/m^2$.

TOTAL: $2600\,N/m^2$.

c.f. actual approx. 2500 N/m^2

Warm-up 3

Q: Sheldon jumps into Okanagan Lake. By how much does the water level rise?

A: My volume $\approx 70\ L = 0.07\ m^3$

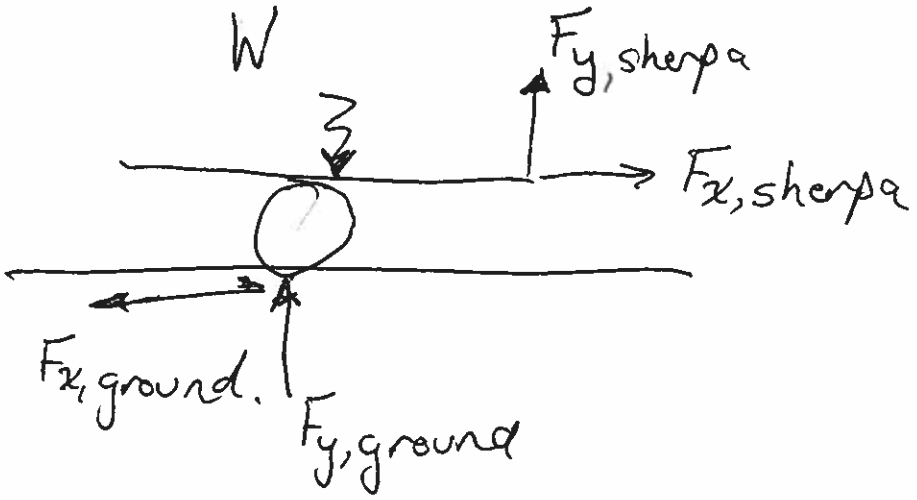
Area of lake $\approx 340\ km^2 = 3.4 \times 10^8\ m^2$.

$\therefore$ change in elevation $\approx \frac{0.07}{3.5 \times 10^8} \sim \underline{2 \times 10^{-10}\ m}$

Trailrider Estimation

Force

- Always start with a free body diagram!



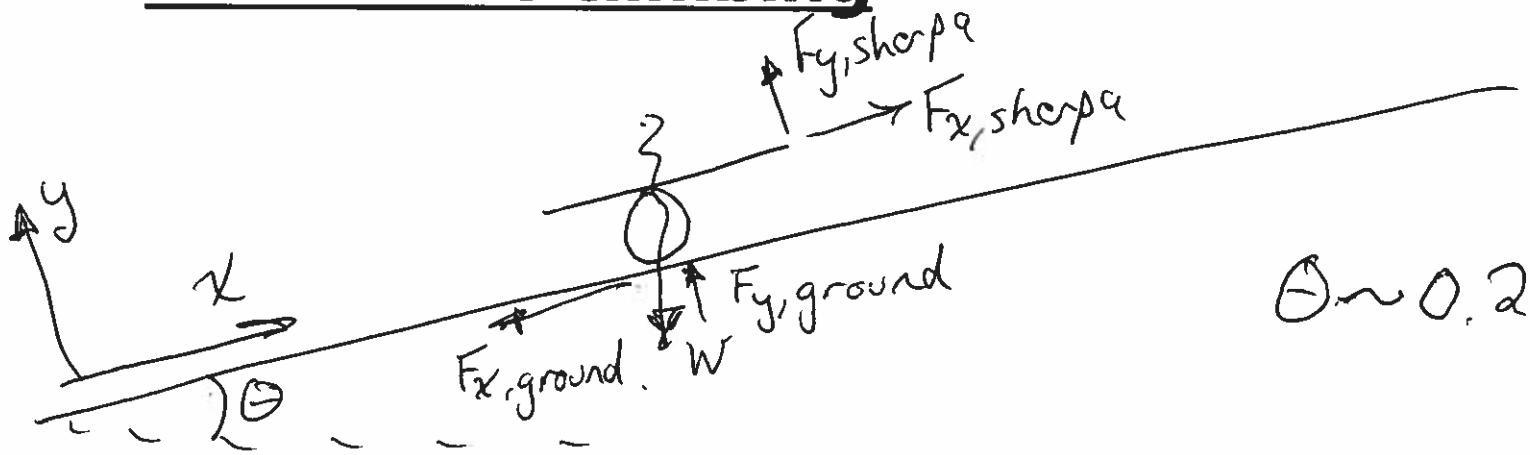
$F_{y,sherpa} \sim 0 \Rightarrow F_{y,ground} = W \sim 1000\,N$

$\therefore F_{x,ground} = C_{rr} W \qquad C_{rr} \sim 0.05$

$\therefore F_{x,sherpa} \sim \underline{50\,N}$

Trailrider Estimation

Force while climbing



$\theta \sim 0.2$ rad.

$$\sum F_x = 0 \Rightarrow \underbrace{F_{x,ground}}_{50} + \underbrace{W \sin\theta}_{200} = F_{x,sherpa}$$

$$\therefore F_{x,sherpa} \sim 250\ N$$

Trailrider Estimation

Speed Required

Typical Person takes 1hr ≈ 3600s to climb G.C.

Course Aerial distance = 2.9 Km = 2900 m

$\therefore V \sim 1 \text{ m/s}$

Trailrider Estimation

Power Required

$$P \sim F \cdot V = 250\,N \cdot 1\,m/s = 250\,W$$

Trailrider Estimation

Power Available

- **Sherpas** : ~300 W/Sherpa, but ~100W is used by Sherpa to move her/himself
  ∴ ~200W x2 = 400W available

- **Rider** : Upper body weaker than legs & buttocks
  Review of literature suggests elite wheelchair athletes can generate ~50W