Final Portfolio

MEAM 247
2023C

Ashna Khemani

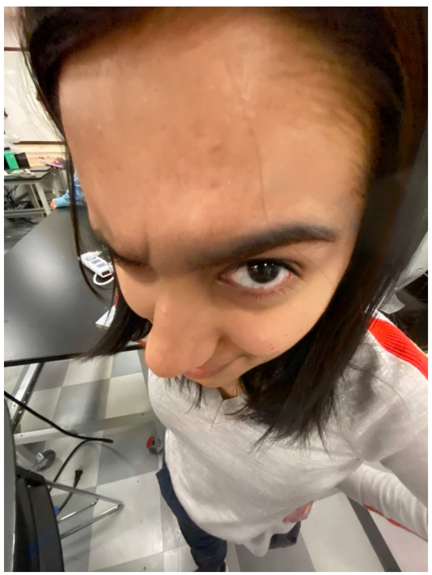
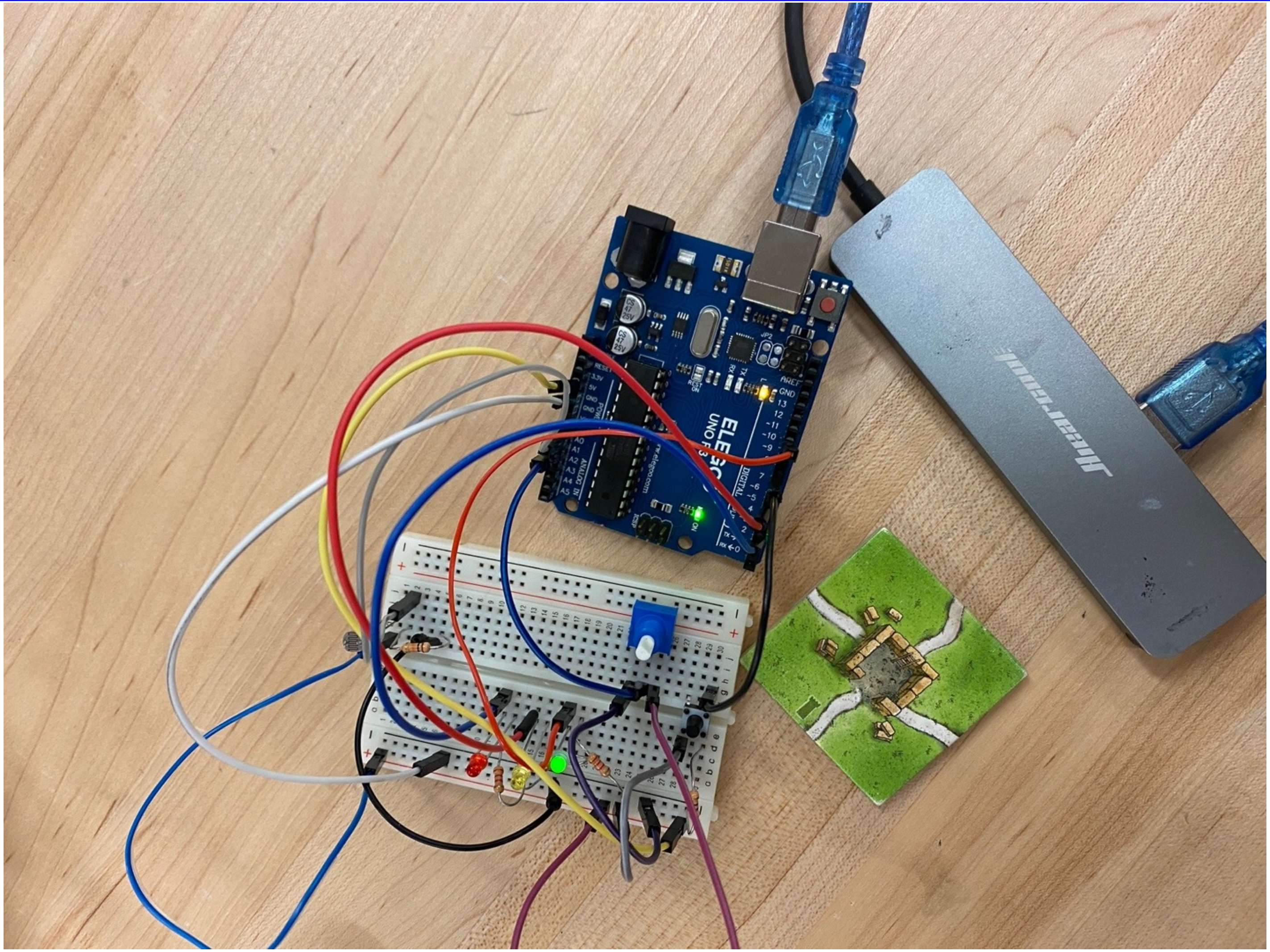


Figure 1: Ashna thinking very hard about drag over spheres in Lab 7

Figure 2: Ashna + friends featured on MEAM Instagram!

Penn Engineering

Lab1: Night Light (Photo & Code Screenshot)



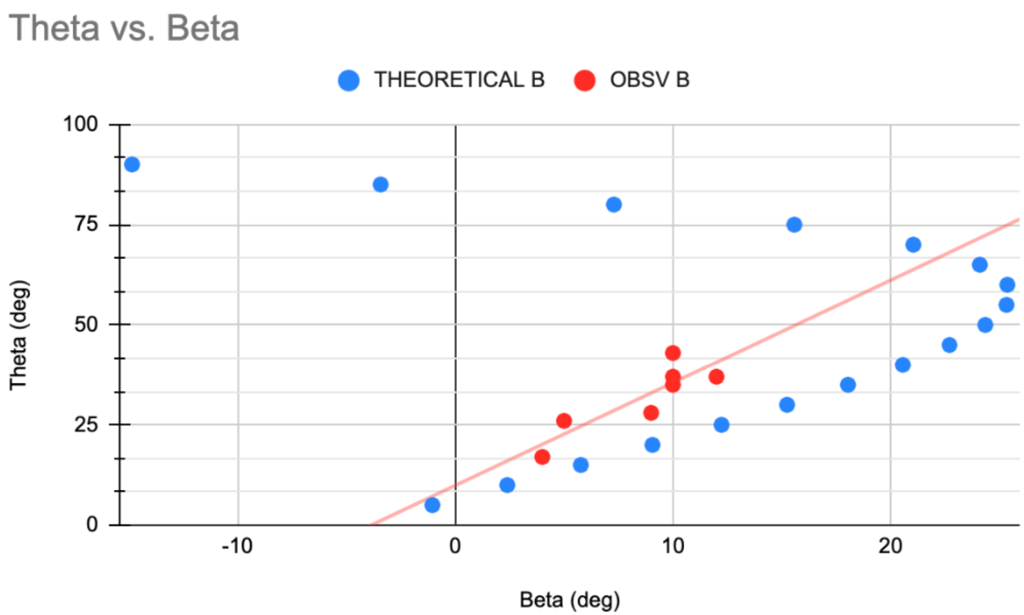
Lab1: Night Light (Photo & Code Screenshot)

```
const int photo = A0;
const int pot = A1;

const int red = 2;
const int yellow = 5;
const int green = 10;
const int button = 7;

bool em_printed = false;
bool red_printed = false;
bool yellow_printed = false;
bool green_printed = false;

void setup() {
    pinMode(photo, INPUT);
    pinMode(pot, INPUT);
    pinMode(button, INPUT);

    pinMode(red, OUTPUT);
    pinMode(yellow, OUTPUT);
    pinMode(green, OUTPUT);

    Serial.begin(9600);

}
```

```
// thresh plus dial status (after mapping 0-500)
void loop() {
    int light = analogRead(photo);
    int potValue = analogRead(pot);
    int potMapped = map(potValue, 0, 1024, 0, 500);
    int buttonValue = digitalRead(button);


    int redThresh = 500 + potMapped;
    int yellowThresh = redThresh + 100;

    if (light<redThresh){ // red light
        digitalWrite(red, HIGH);
        digitalWrite(yellow, LOW);
        digitalWrite(green, LOW);
        if(!red_printed){
            Serial.println("red");
            red_printed = true;
            yellow_printed = false;
            green_printed = false;
        }
    }
    else if (light>redThresh && light<yellowThresh){ // yellow light
        digitalWrite(yellow, HIGH);
        digitalWrite(red, LOW);
        digitalWrite(green, LOW);
        if(!yellow_printed){
            Serial.println("yellow");
            red_printed = false;
            yellow_printed = true;
            green_printed = false;
        }
    }
    else if (light>yellowThresh){    // green light
        digitalWrite(green, HIGH);
        digitalWrite(red, LOW);
        digitalWrite(yellow, LOW);
        if(!green_printed){
            Serial.println("green");
            red_printed = false;
            yellow_printed = false;
            green_printed = true;
        }
    }


    if (buttonValue==HIGH){        // button
        digitalWrite(red, HIGH);
        digitalWrite(yellow, HIGH);
        digitalWrite(green, HIGH);
        if (!em_printed){
            Serial.println("EMERGENCY");
            em_printed = true;
        }
      }
    else{
        em_printed = false;
    }

    delay(250);
}
```

Lab2: Updated Fluid Graphs & Analysis

Fountain – observed data points (red) measured by Vidhya K.; empirical observations to find M in calculations (u and h) measured by Josh L.; table, graph, best fit line, all other calculations and work produced by me



$$\tan\theta = 2\cot\beta\,\frac{M_1^2\sin^2\beta - 1}{M_1^2(\gamma + \cos 2\beta) + 2}$$

$\gamma = 1.4$ $\quad M_1 = F_r = \frac{u}{\sqrt{gh}}$ $\quad u = 2\,\text{ft}/1.16\,\text{s.} = 0.526\,\text{m/s}$

$h = \frac{1}{4}\,\text{in} = 0.00635\,\text{m}$

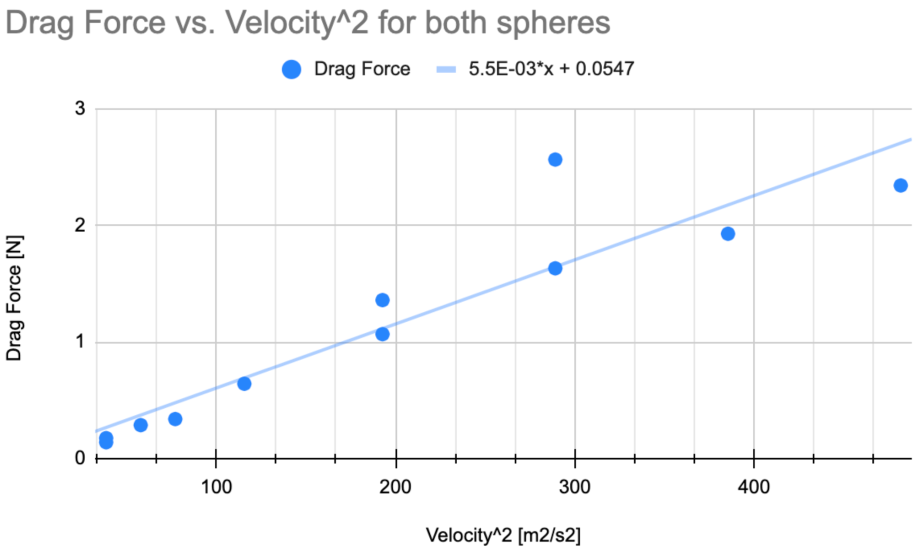
$$M_1 = \frac{0.526}{\sqrt{9.81\times 0.00635}} = 2.106$$

$$\theta(\beta) = \underbrace{\tan^{-1}}_{\text{col F}}\left[\underbrace{2\cot(\beta)}_{\text{col C}}\,\frac{\overbrace{M^2\sin^2(\beta) - 1}^{\text{col D}}}{\underbrace{M^2(\gamma + \cos(2\beta)) + 2}_{\text{col E}}}\right]$$

col A: β in deg
Col B: $\beta \rightarrow$ rad
col G: $\theta_{rad} \rightarrow \theta_{deg}$

Lab2: Updated Fluid Graphs & Analysis

Wind Tunnel – Calculations done independently. Table by Vidhya K., graph produced by me



ESTIMATING C_d W/ TRENDLINE

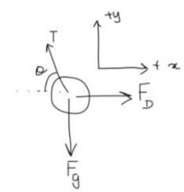
$$F_d = 0.0055\, v^2$$

$$0.0055 = \frac{1}{2} \rho_{air} C_d A$$

From earlier:

$\rho_{air} = 1.293\ kg/m^3$ $A = 0.01267\ [m^2]$

$$\Rightarrow C_d = \frac{2 \times 0.0055}{\rho_{air} \times A} = \boxed{0.6715}$$



Heavy ball (Red)

$m = 0.512$ kg

$\theta = 65°$

$T \sin 65 = 0.512 (9.81)$

$T = 5.64$ [N]

$F_D = 5.64 \cos 65$

$\boxed{F_D = 2.38\ [N]}$

$\Sigma F_x = 0 = F_D - T\cos\theta$

$\Sigma F_y = 0 = -F_g + T\sin\theta$

$A = 0.01267$ $[m^2]$

$F_D = 2.38$ [N]

$\rho_a = 1.293\ kg/m^3$

$u = ?$

$$c_d = \frac{2F_D}{\rho_a u^2 A}$$

$P_1 + \frac{1}{2}\rho_a v_1^2 = P_2 + \frac{1}{2}\rho_a v_2^2$

$\frac{1}{2}\rho_a v_1^2 = \Delta P + \cancel{\frac{1}{2}\rho_a v_2^2} \rightarrow 0$

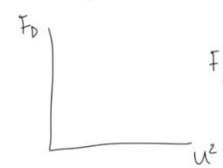
$\frac{1}{2}\rho_a V_1^2 = \Delta P$

$\Delta P = ?$ $\Delta h = 0.03175$ [m] $\rho_f = 1000 kg/m^3$

$\Delta P = \rho_f g \Delta h = 1000 \times 9.81 \times \Delta h$

$\Delta P = 311.4675$ [Pa]

$v_1^2 = \frac{2\Delta P}{\rho_a} = 481.775$



$F_D = \frac{1}{2}\rho u^2 c_d A$

Lab3: Fracture & Buckling: Photos, Tables, Analysis

Group 2: Ashna Khemani, Christine Meng, Jonas Ho, Justin Russell

Wood Dowel (Theoretical)							
Length (in)	Diameter (in)	Length (m)	Diameter (m)	K	I (m^4)	Youngs Modulus (Pa)	Buckling Force (N)
48	0.25	1.2192	0.00635	1	0.00000000007981138	8000000000	4.239402233

https://www.engineeringtoolbox.com/euler-column-formula-d_1813.html

Wood Dowel (Experimental)	
Experimental load (g)	Newtons
500	4.905

Experimental and theoretical buckling forces are very close.

Experiment: push down along length of dowel on top of scale until dowel starts buckling.

Metal (Experimental) - Group 2	
Mass (kg)	0.064
Length (in)	5.978
Width (in)	0.455
Height (in)	0.211
Max N	13374.405
Max displacement (mm)	2
Material	Cast Iron
Known Max N	2.48E+04
% Elongation at break	1.472165875
Volume (m3)	9.40E-06
Density (kg/m3)	6.81E+03
Ultimate tensile stress	215930099.6
Ultimate tensile stress (MPa)	215.9300996

Group 2 Metal (Theoretical)	
X sec area (m^2)	Google Ultimate Tensile stress (Pa)
0.0000619385858	4.00E+08

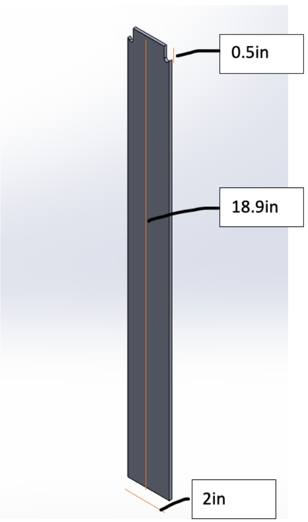
Known Max N and Max N are pretty close (same OoM).

Experiment: put strip of metal in MTS machine. Pull it until it breaks.

Lab4: Suspension Bridge Analysis & Test Photo

Lab 4 Individual Assignment

Ashna Khemani – Tower Officer



- 18.9in total length, 0.5in from tip of cable holds to top of tower.
- Each tower will be 2x 1/8'' MDF sheets glued together
- 2in base width, 1.8in top width

Calculation for critical force:

$$F_{cr} = \frac{\pi^2 EI}{(KL)^2}$$

- E is modulus of elasticity. $E = 0.58 * 10^8 \left[\frac{lb}{in^2}\right]$ for MDF according to this
- I is area moment of inertia
  - For this rectangular base, $I = \frac{bh^3}{12}$; $b = 2[in], h = \frac{1}{4}[in]$
  - $I = \frac{2*\left(\frac{1}{4}\right)^3}{12} = 0.0026\ [in^4]$
- $K = 2$ for our support, which is fixed at the bottom and free at the top according to this
- $L = 18.9\ [in]$

$$F_{cr} = \frac{\pi^2(0.58 * 10^8)(0.0026)}{(2 * 18.9)^2} = 1043\ [lb]$$

I'm a little suspicious of this. A person could probably break an 18.9in long piece of MDF with their bare hands, exerting less than ~1000 pounds of force. I wonder if the issue is the Young's modulus for MDF ($0.58 * 10^8 \left[\frac{lb}{in^2}\right]$) that I found online.

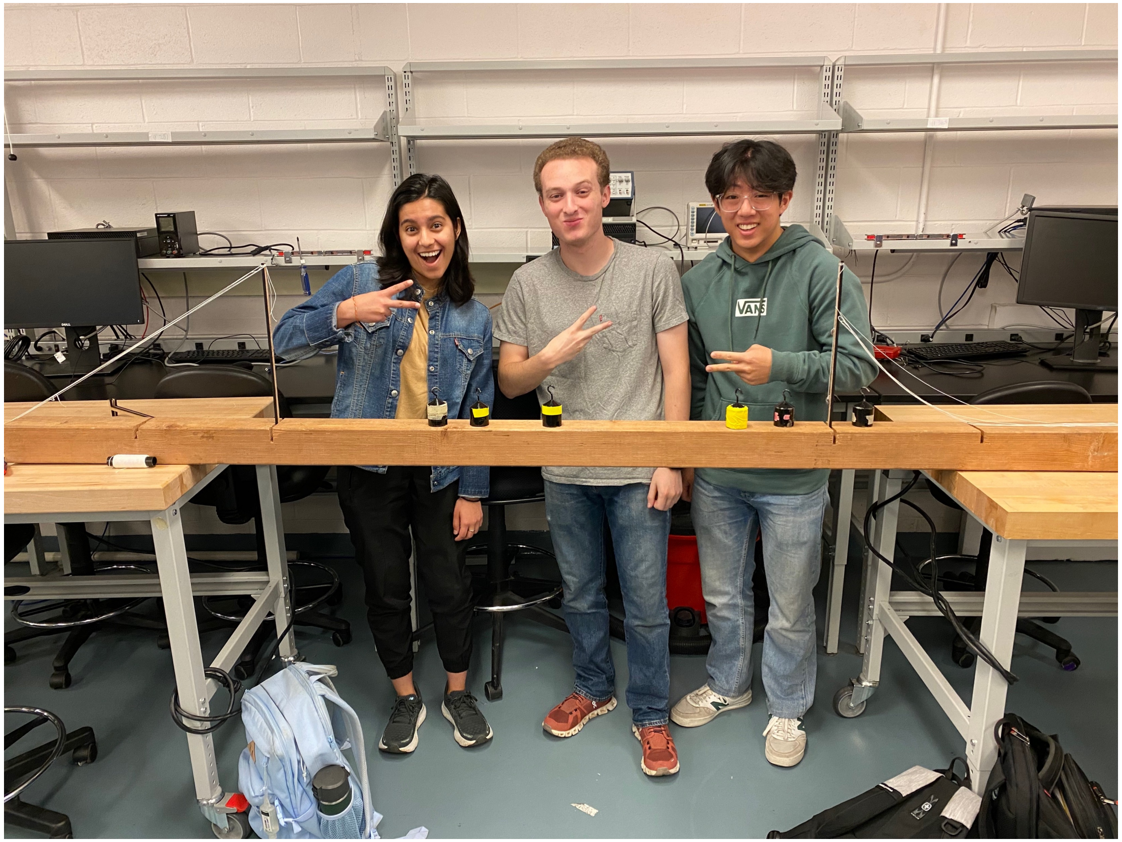
I'll have to do some more research into if such a large F_{cr} is reasonable.

But if this is right, then this could definitely support the projected load of 40N:

$40[N] < 1043[lb] = 4639.5[N]$

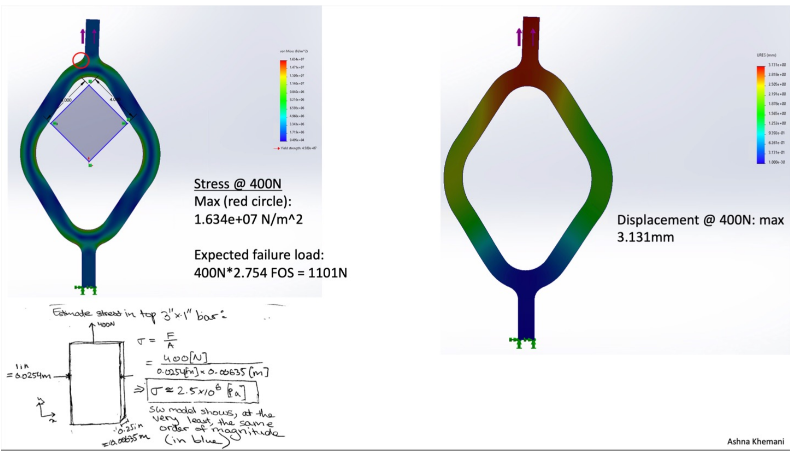
But again, this seems a little fishy to me. 🐟

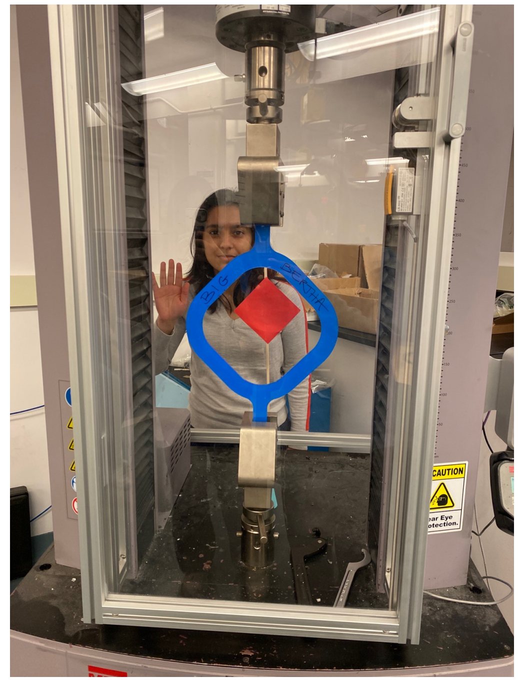
Lab4: Suspension Bridge Analysis & Test Photo



Almost worked but broke ☹
We overoptimized cost at the expense of performance. Our towers didn't distribute tension over the cables evenly. So while our towers were intact, our cables snapped.
To improve, we'd rely less on the cable to hold everything together, and instead spend more money on the towers themselves. We might make a structure that has more depth along the length of the bridge, to avoid overbending while supporting more of the load.

Lab5: Tension Strap Final FEA & Test Photo



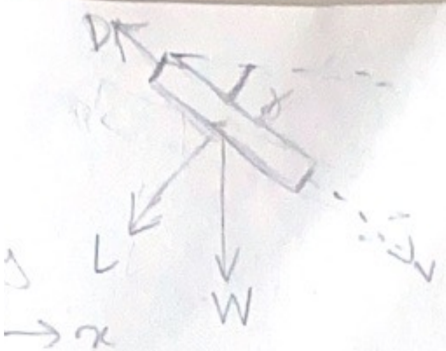


A wistful goodbye to my beloved Big Bertha

~1000[N] later…

Lab6: Airplane Flight Test Media & Graph

FBD + equation

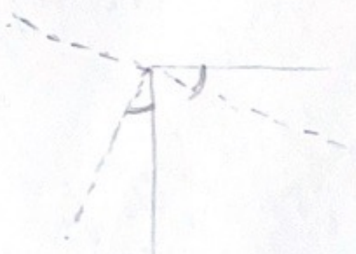


Equilibrium: $\Sigma F_x = 0 \rightarrow -D\cos\gamma - L\sin\gamma = 0$

$\hookrightarrow -D\cos\gamma = L\sin\gamma$ (1)

$\Sigma F_y = 0 \longrightarrow D\sin\gamma - L\cos\gamma - W = 0$

$\hookrightarrow D\sin\gamma = L\cos\gamma + W$ (2)



$$\frac{(1)}{(2)} \rightarrow -\tan\gamma = \frac{L\cos\gamma + W}{L\sin\gamma}$$

$$-\tan\gamma = \frac{D\sin\gamma}{L\sin\gamma}$$

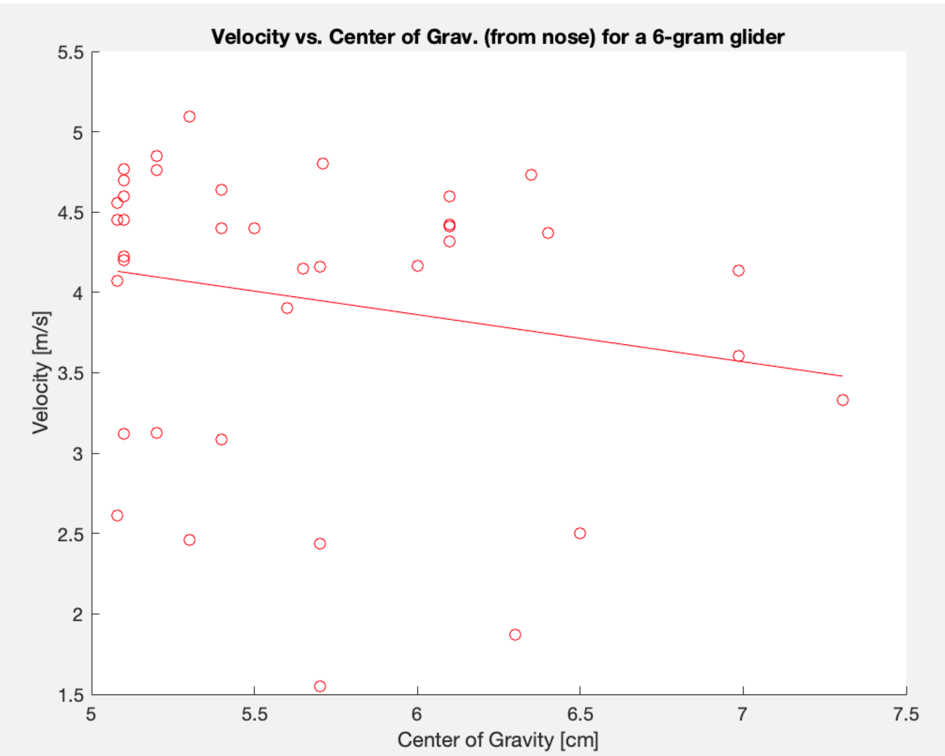
$$\boxed{\tan\gamma = \frac{-D}{L}}$$

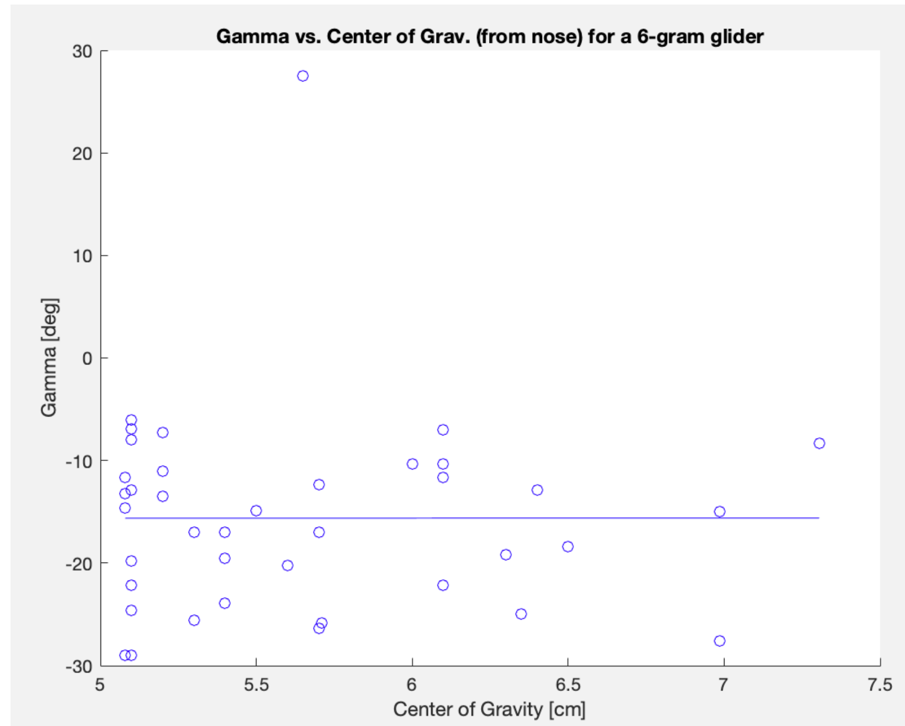
Lab6: Airplane Flight Test Media & Graph

Flight Videos (with Kayla)

Lab6: Airplane Flight Test Media & Graph

Graphs (from 10:15 section class data)





Hard to find patterns; noisy data ☹
Would need more stable flight throws.

Lab7: Load Cell Explanation & Sphere Drag Graph

Load cell explanation

Load cell: bend beam → elongates and reduces cross section of the squiggly wire across the deforming surface

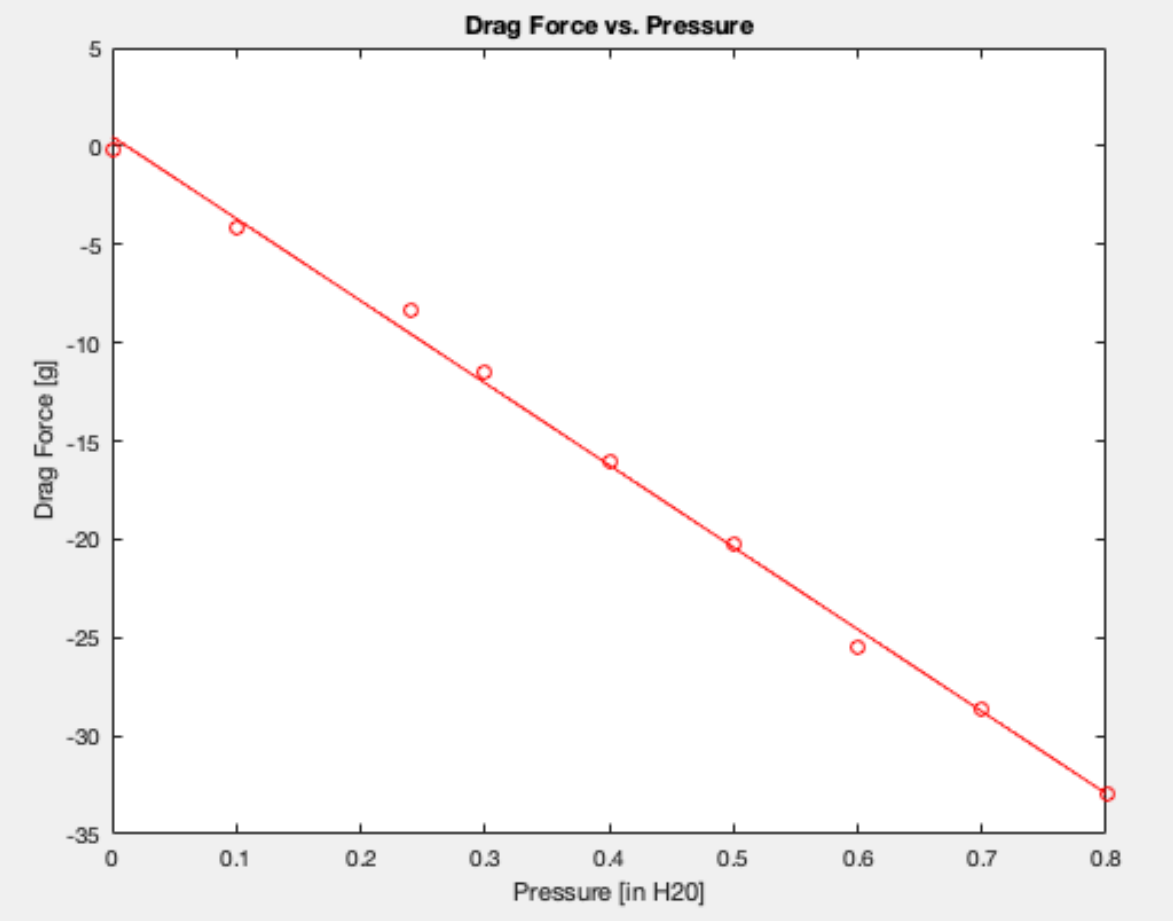
$$R = \frac{\rho L}{A}$$

Measure the change in resistance (the change in voltage drop) across the wire → can give you an idea of how much the wire deformed → how much the beam bent

Lab7: Load Cell Explanation & Sphere Drag Graph

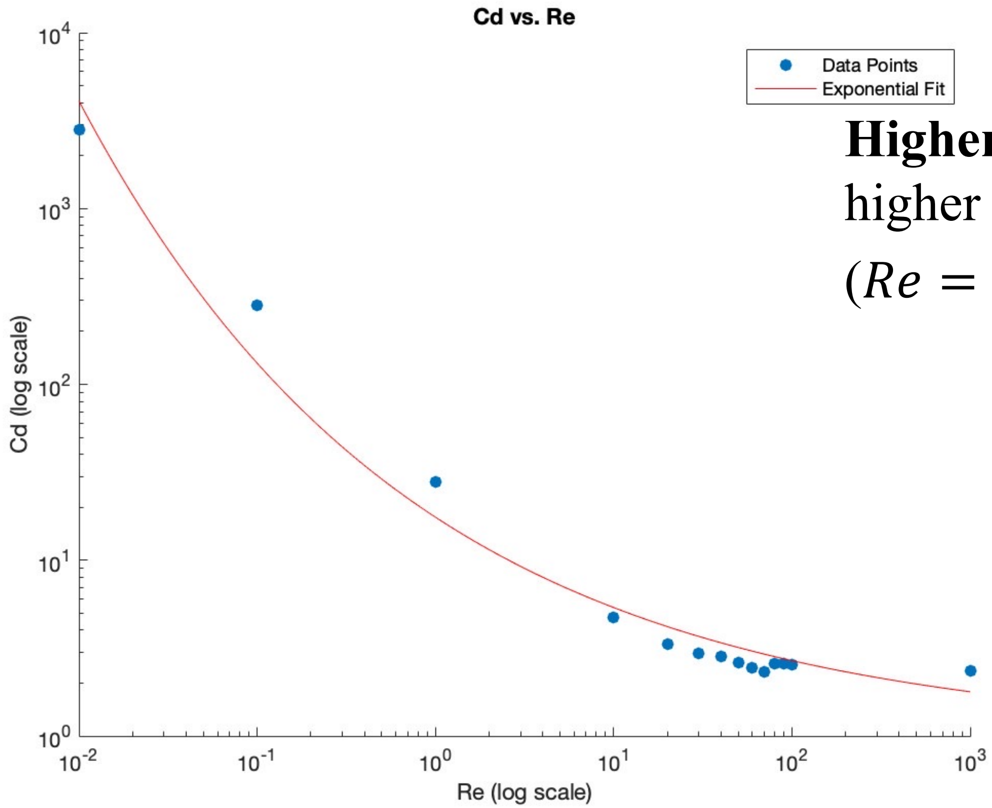
Sphere Drag Graph (data from 10:15 section)

	A	B
1	Pressure (inches of H2O)	Drag Force (g)
2	0	-0.15
3	0.1	-4.2
4	0.24	-8.35
5	0.3	-11.5
6	0.4	-16.1
7	0.5	-20.2
8	0.6	-25.5
9	0.7	-28.7
10	0.8	-33



Lab7: Load Cell Explanation & Sphere Drag Graph

Makes sense, compared to MEAM 2020 project (view here)



Higher (dynamic) pressure → higher velocity → higher Re ($Re = \frac{\rho v L}{\mu}$) → **higher C_d**

Looking Forward in Learning & Life

- Stuff I'm Excited to Learn Next
  - How and why stuff flies
    - Maybe more about aerodynamics? Fluids? ???
  - Data science, machine learning, AI… *insert more Silicon Valley-esque buzzwords, but genuinely*
  - How To Robot and Why To Robot
    - Humanitarian causes/disaster relief
    - Safety in manufacturing, human + robot collaboration
- Where I See Myself in 5 Years
  - **If money wasn't an issue:** teaching high school engineering/math/sci., coaching robotics teams, generally helping kids find a love for hands-on engineering
  - **Maybe:** MSE in Robotics? MBA? Both? Who knows.
  - **Hopefully:** making robots and systems that are actually useful (space rovers, drones, legged bots). ***<u>Doing hands-on work.</u>***
  - **But it would be cool** to be a leader/specialist in a company with fresh and funky ideas…
    - Will it work? Who knows!
    - Will it be cool? Yeah!
    - Will it inspire others to get on board? I hope so!

Interesting Stuff

Theater = fun

Three-Body Problem is literal chaos but kinda cool