

SMARTBEAM

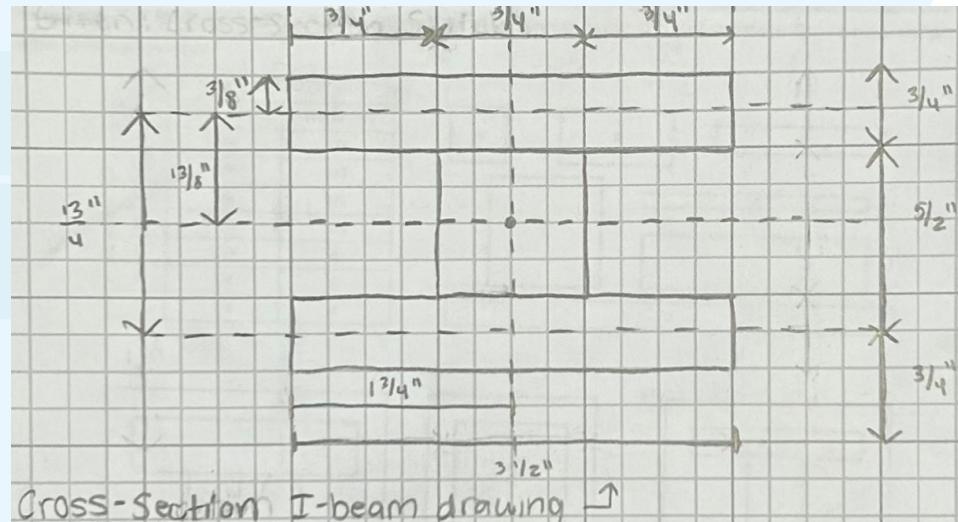
Group 1-1

Ahmed, Hunter, Marigrace, Mia, and Ryan



Overall Goal

- Design a SMARTBEAM
- Design Strain-Monitoring System
- Perform Deflection Testing
- Understanding of core Civil and Computer Engineering concepts

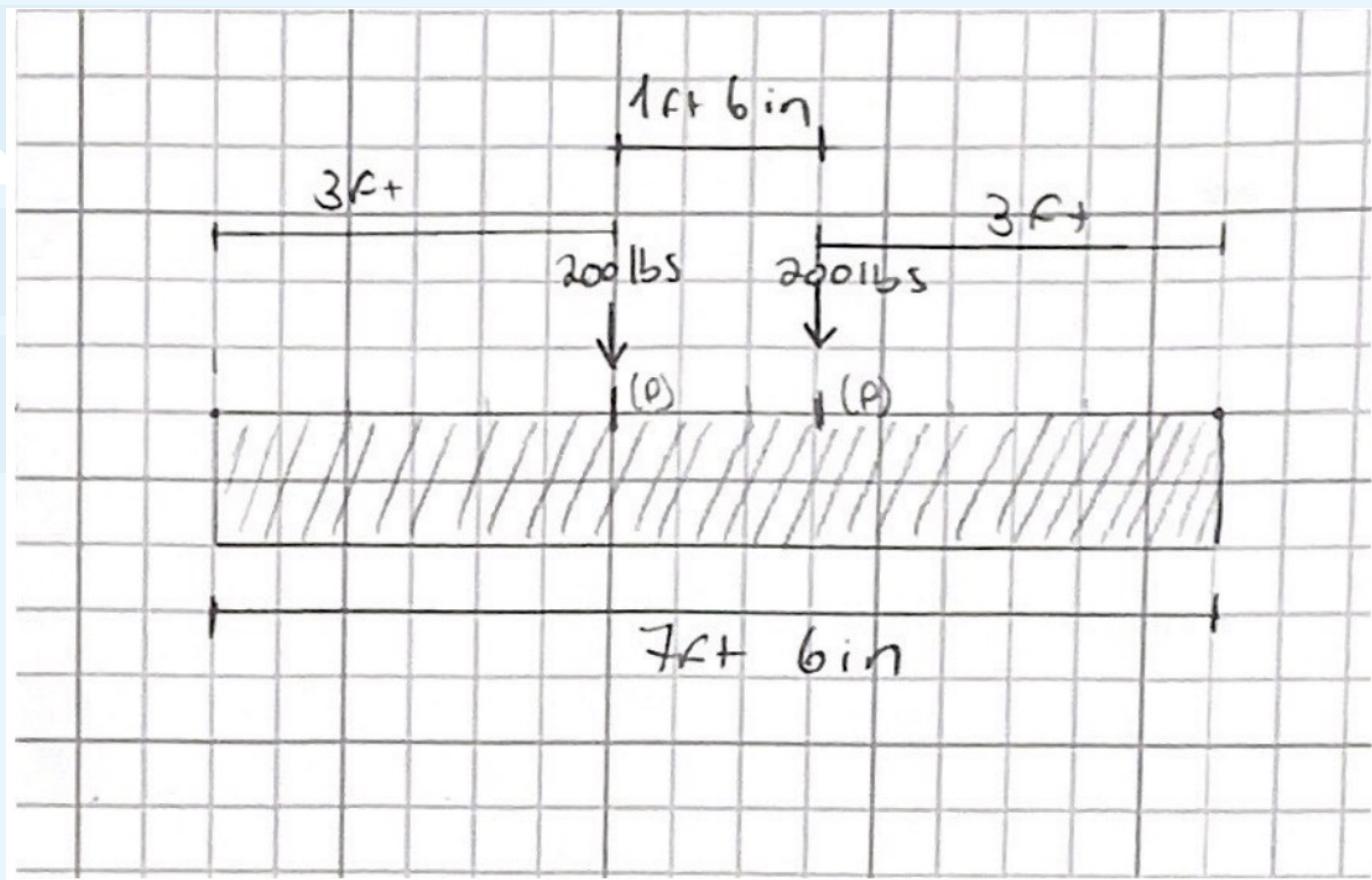


Requirements & Constraints

- 1 The beam deflection should be limited to a maximum midspan deflection of 0.25in.
- 2 The flexural strain anywhere in the beam should be limited to a maximum of $800\mu\varepsilon$
- 3 Beam span 7.5 feet & load of 400lbs (distributed to 2 points of 200lbs each). Cost is also to be limited



Beam



Designing Approach (Finding Elasticity)

- Finding average modulus of elasticity from wood beam samples

- Required calculating moment of inertia for (1x2, 1x3, 1x4, 1x5) using $\frac{bh^3}{12}$

Size	h (in)	b (in)	Moment of Inertia (in ⁴)
1x2	0.75	1.50	0.052734375
1x3	0.75	2.50	0.087890625
1x4	0.75	3.50	0.123046875
1x5	0.75	4.50	0.158203125

- Calculated Modulus of Elasticity for Each Sample using $\frac{Pa^2b^2}{3EI}$

P (lbs)	A (in)	B (in)	E(psi)	Inertia, I (in ⁴)	L (in)
2.033	45	45	?	Respective Sample	90

- Average Modulus of Elasticity = 1593222.541 psi



Approach to Designing the Beam

- I-beam, fully connected, glue and screws
- Calculate deflection for two loads using $\frac{Pa}{24EI} (3l^2 - 4a^2)$
- Finding dimensions for I-beam
- < 0.25in deflection (design constraint) meaning the moment of inertia must be > 14.40
- Two 1x4 Boards (Flange Members, Horizontal), one 1x3 Board (Web Member, Vertical)
- Strain must be < 800 (design constraint)...
- Calculated $0.000599117 \text{ u}\varepsilon \approx 599 \varepsilon$

Load P (lbs)	a (in)	L (in)	E, SPF Wood (psi)
200.00	36.00	90.00	1593222.541

$$\varepsilon = \frac{\sigma}{E} \quad \sigma = \frac{M}{S}$$

$$\varepsilon = \frac{Pac}{IE} \quad S = \frac{I}{c}$$

Orientation	I-beam Inertia (in ⁴)	Deflection (in)
1x4 - 1x3	15.09	0.238598512

$$\frac{bh^3}{12}$$

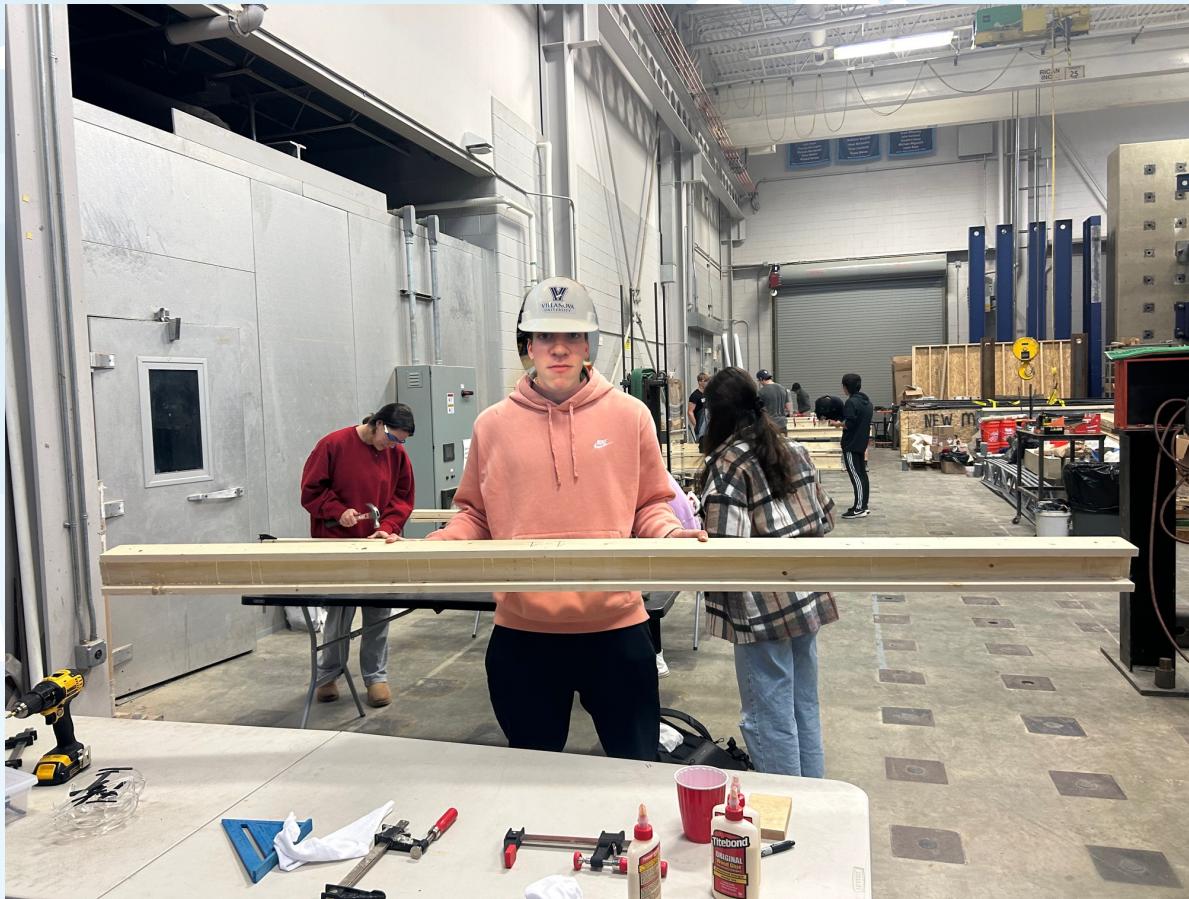


How We Built Our Beam

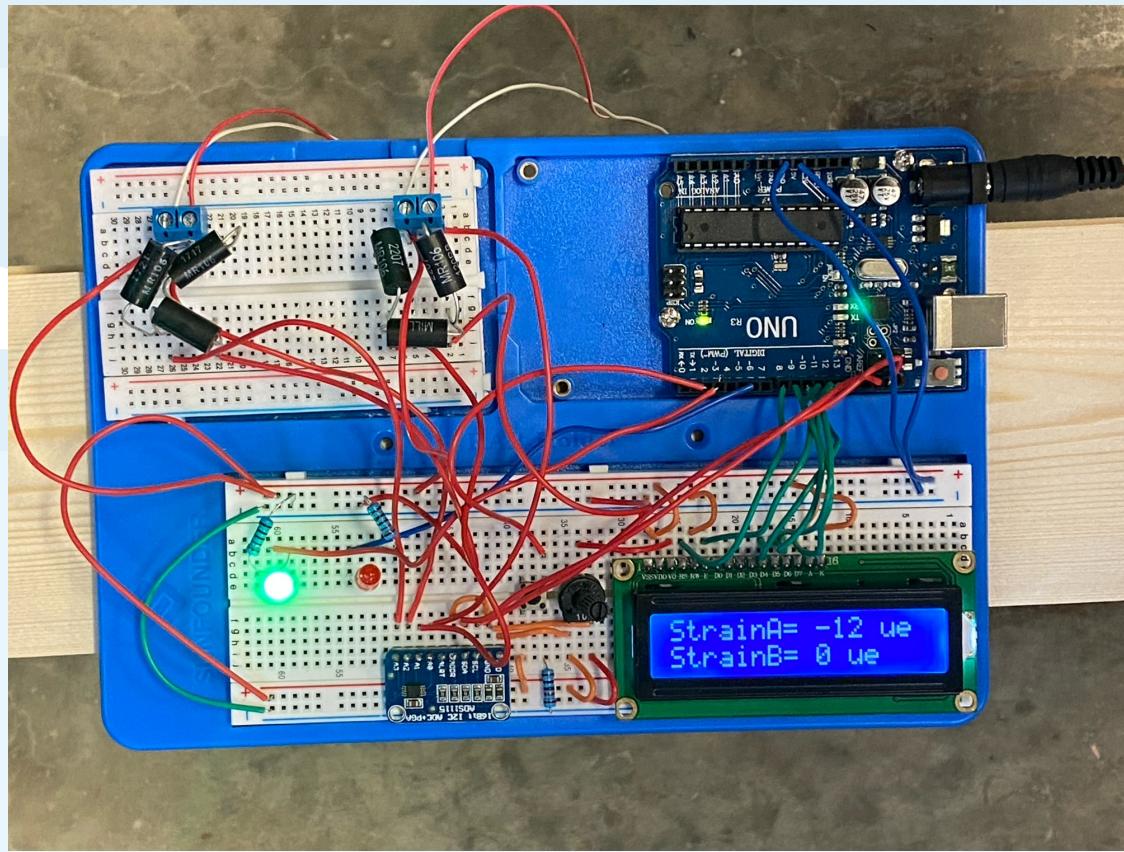
- (2) 1x4 flange members & (1) 1x3 web member
- Fully connected
- Screws – 8 2-inch
- Glue – 3 8-oz bottles



Finished Beam!



Strain Monitoring System



Intended Use

- Strain gauges report compressive (-) & tensile (+) strain
- LCD constantly displays both strain values
- Light-based monitoring relies on the largest absolute strain value
- Green LED to indicate the system is OK while straining $< 600\mu\varepsilon$
- Flashing red LED for strain values $\geq 600\mu\varepsilon$
- Speed between red light blinks is linear to strain until $800\mu\varepsilon$

```
void loop()
{
    // ...
    int maxStrain = highestStrain(strainA, strainB);
    int blinkSpeedMS = blinkSpeed(maxStrain);
    if (blinkSpeedMS == 0)
    {
        digitalWrite(redLED, LOW);
        digitalWrite(greenLED, HIGH);
    }
    else
    {
        digitalWrite(greenLED, LOW);
        blink(blinkSpeedMS);
    }
}

// ...

int highestStrain(int strainA, int strainB)
{
    int absStrainA = abs(strainA);
    int absStrainB = abs(strainB);

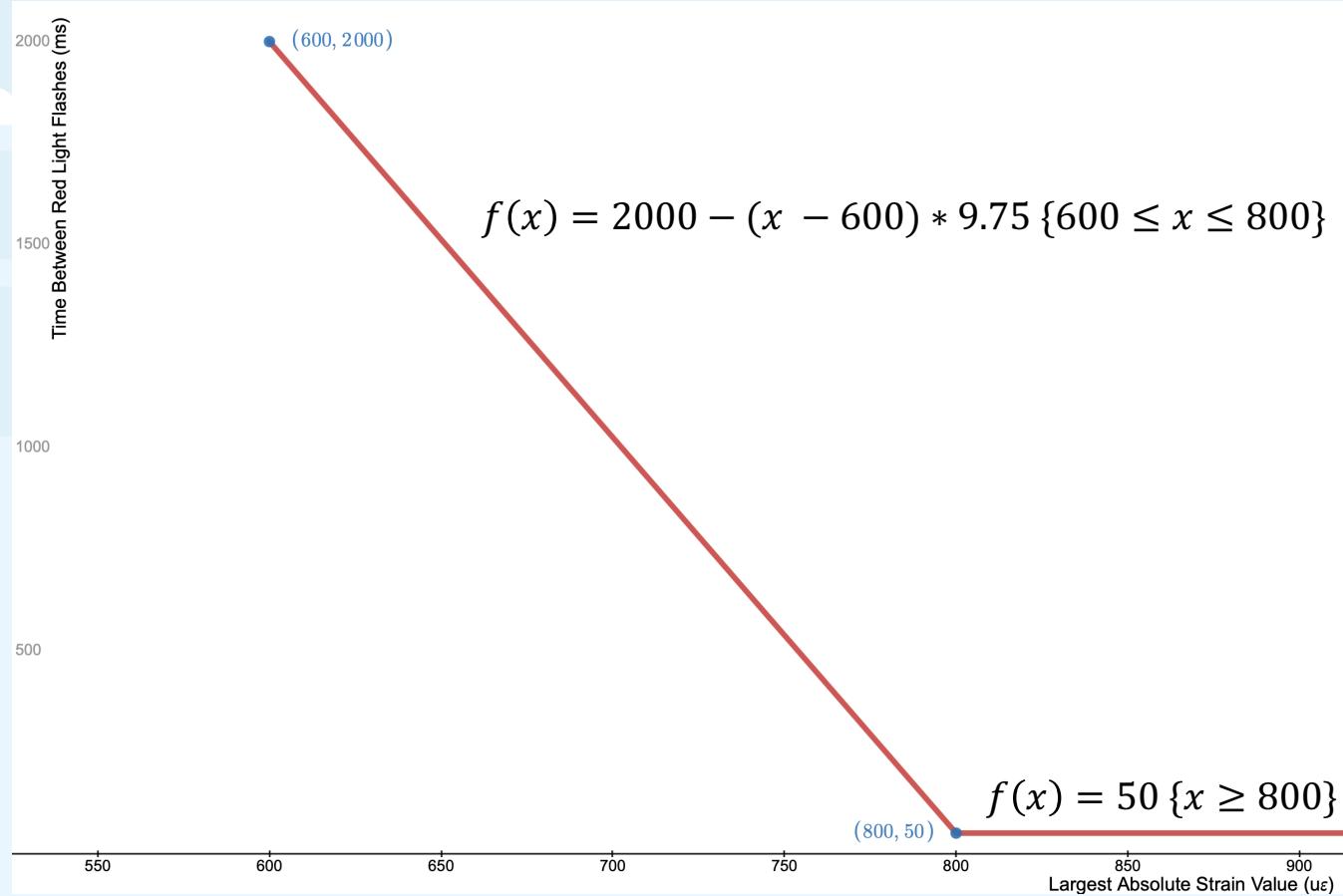
    if (absStrainA >= absStrainB)
        return absStrainA;
    else
        return absStrainB;
}

int blinkSpeed(int strain)
{
    int absStrain = strain;
    int blinkSpeedMS;

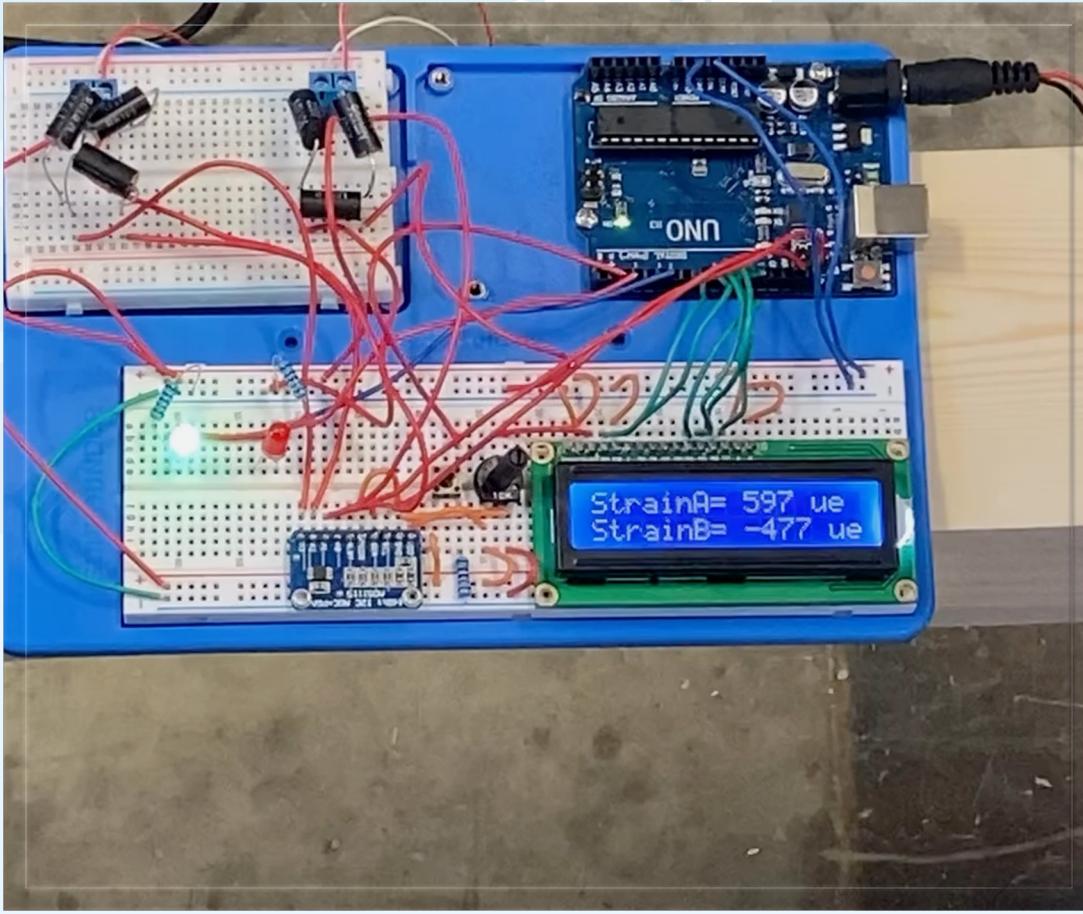
    if (absStrain < 600)
    {
        blinkSpeedMS = 0;
    }
    else if (absStrain >= 800)
    {
        blinkSpeedMS = 50;
    }
    else
    {
        blinkSpeedMS = 2000 - (absStrain - 600) * 9.75;
    }
    return blinkSpeedMS;
}

void blink(int delayMS)
{
    digitalWrite(redLED, HIGH);
    delay(50);
    digitalWrite(redLED, LOW);
    delay(delayMS);
}
```

Function of Red Light Blink Speed



Did it work?



Predictions

	1	
	prediction	actual
P assigned	400	
ϵ at P	599	406/-337
Δ at P	0.24	0.24
P at ϵ	533	780
P at Δ (lbs)	418	636
P _{failure} (lbs)	1400 max load and beam began to twist. Web was not	
Strain Monitoring Description	<p>Green on < 600 Green off > 600 Red blinks > 600 Blink increases rate until fastest blinking at 800 System worked well.</p>	

Improvements

- Buy less glue (1sq. ft vs 12 sq. ft)
- Place strain gauge B closer to the beam center

StrainA= 802 ue
StrainB= -617 ue

