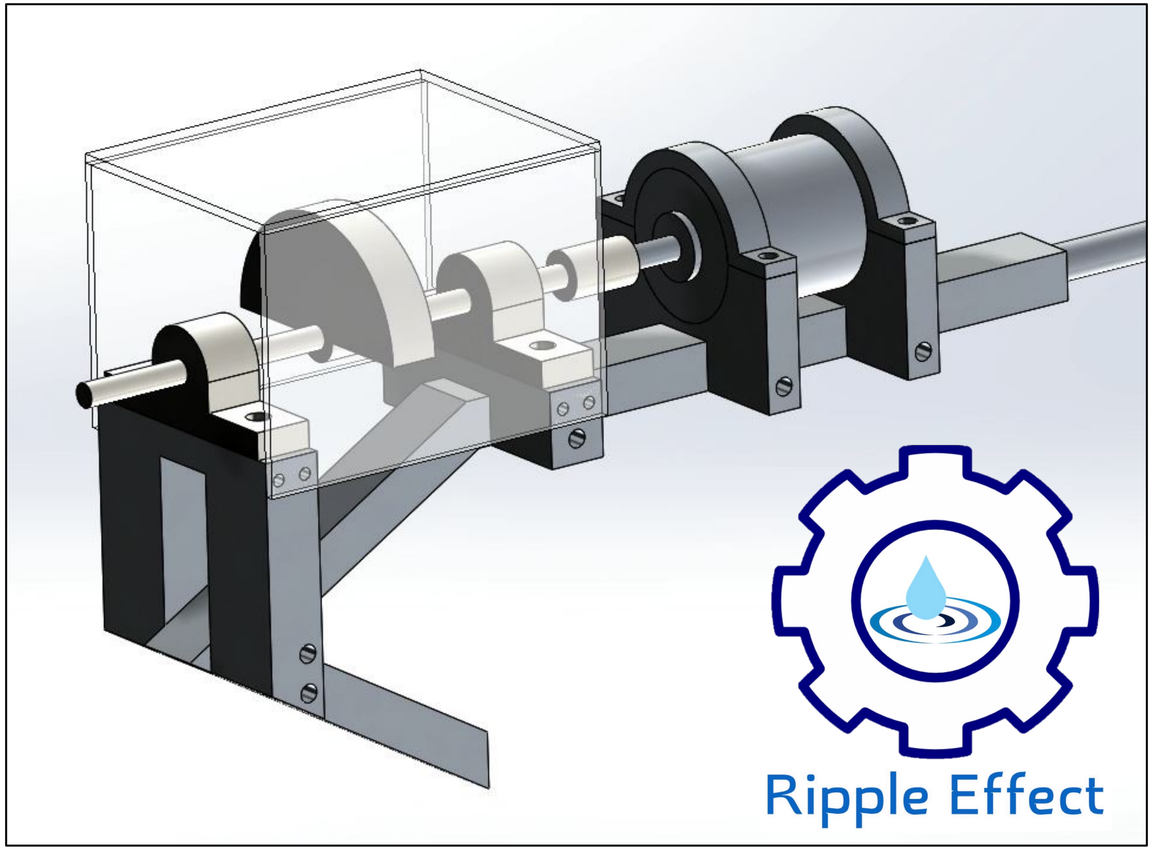
SDII T9 – Design of a Mechanical Mesquite Bean Harvester & Collector

Review 1



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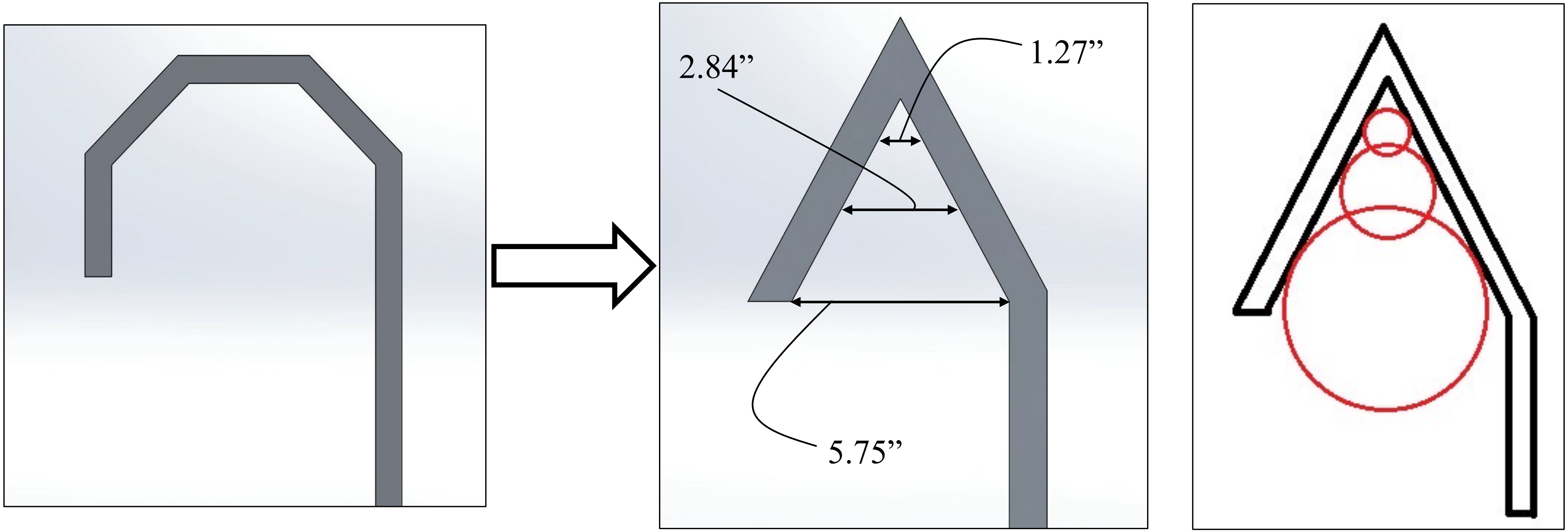
Branch Measurements

Mesquite Tree Branch Diameter Data

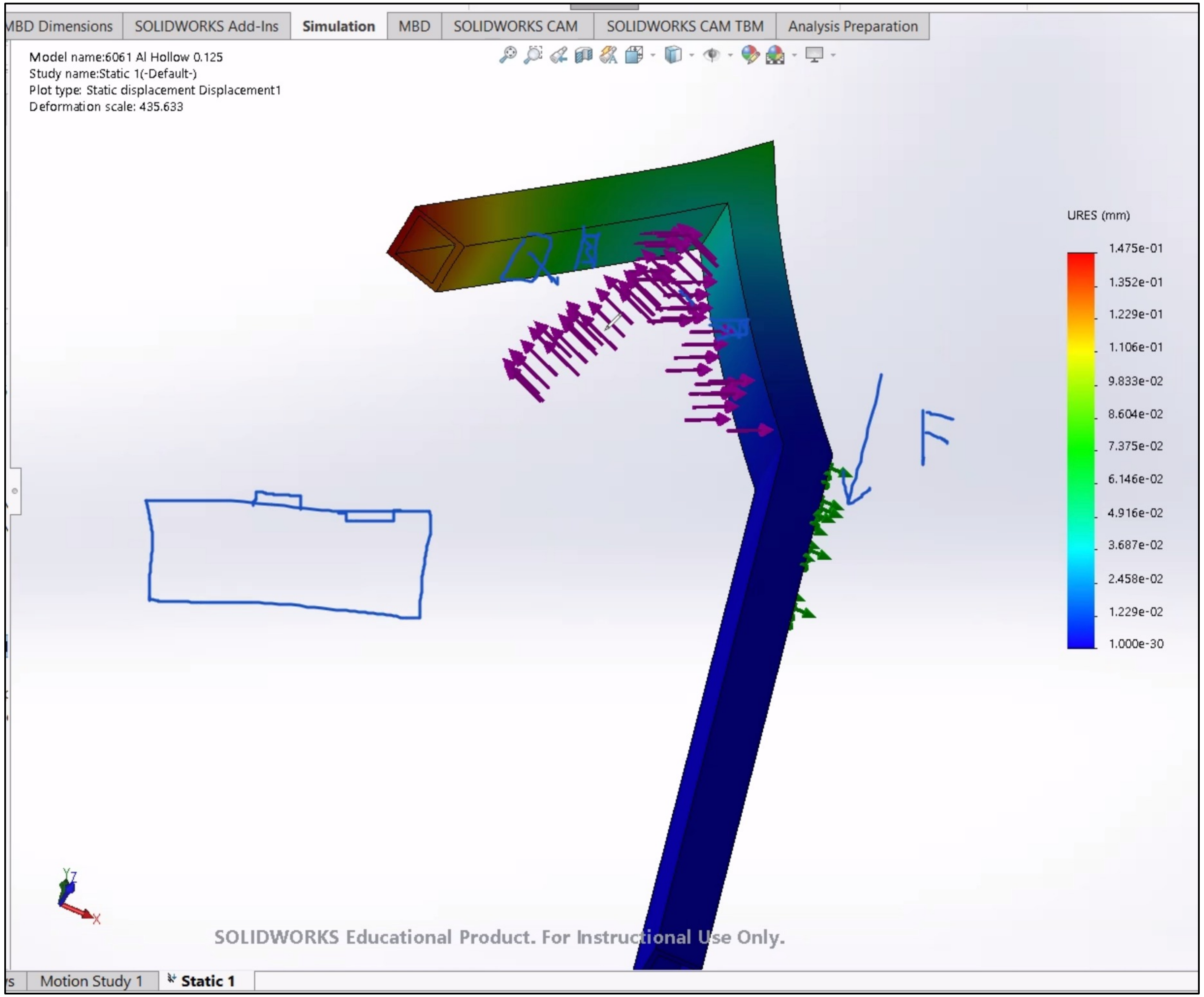
Maximum	5.33”
Minimum	1.27”
Average	2.84”

$$Diameter = \frac{Circumference}{\pi}$$

Hook Redesign

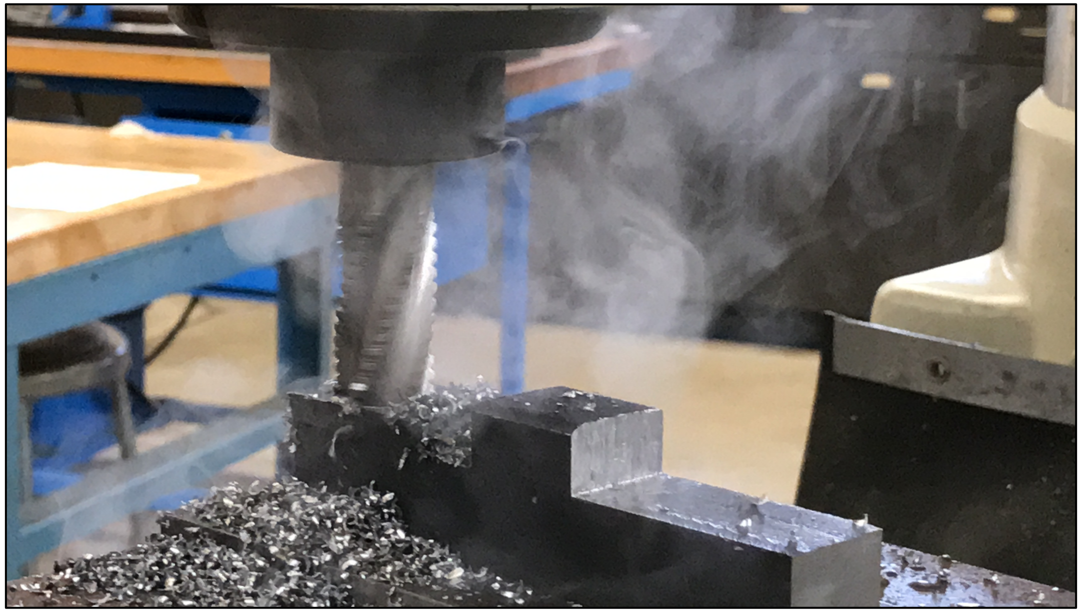


Finite Element Analysis

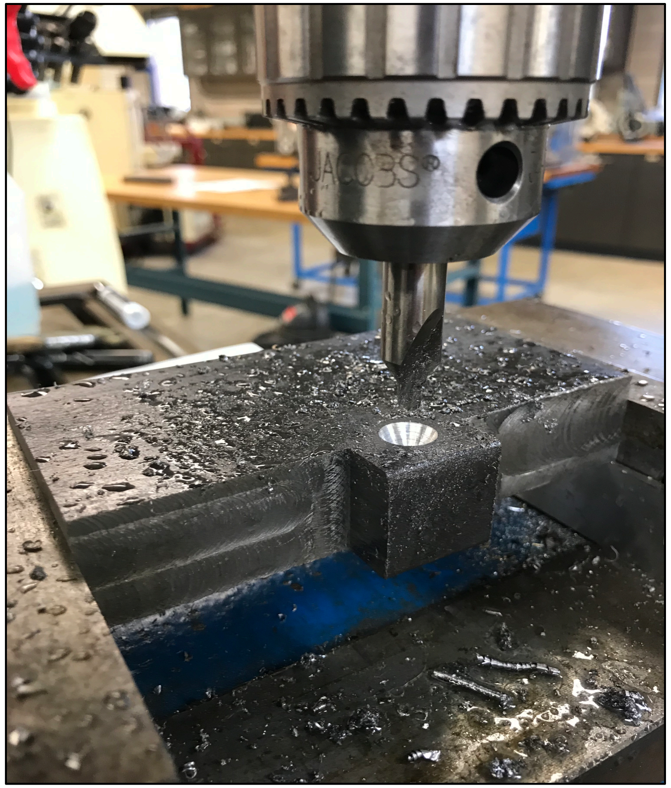


Machining

An endmill is used to cut off the excess aluminum from the upper motor mount (further machining is done with the belt sander).



Offset mass being manufactured with the Milling machine; it's removing material to match the needed dimensions.



The Milling machine is used on the offset mass to mark, and later drill, a ½ inch diameter hole. This is where the shaft will be inserted.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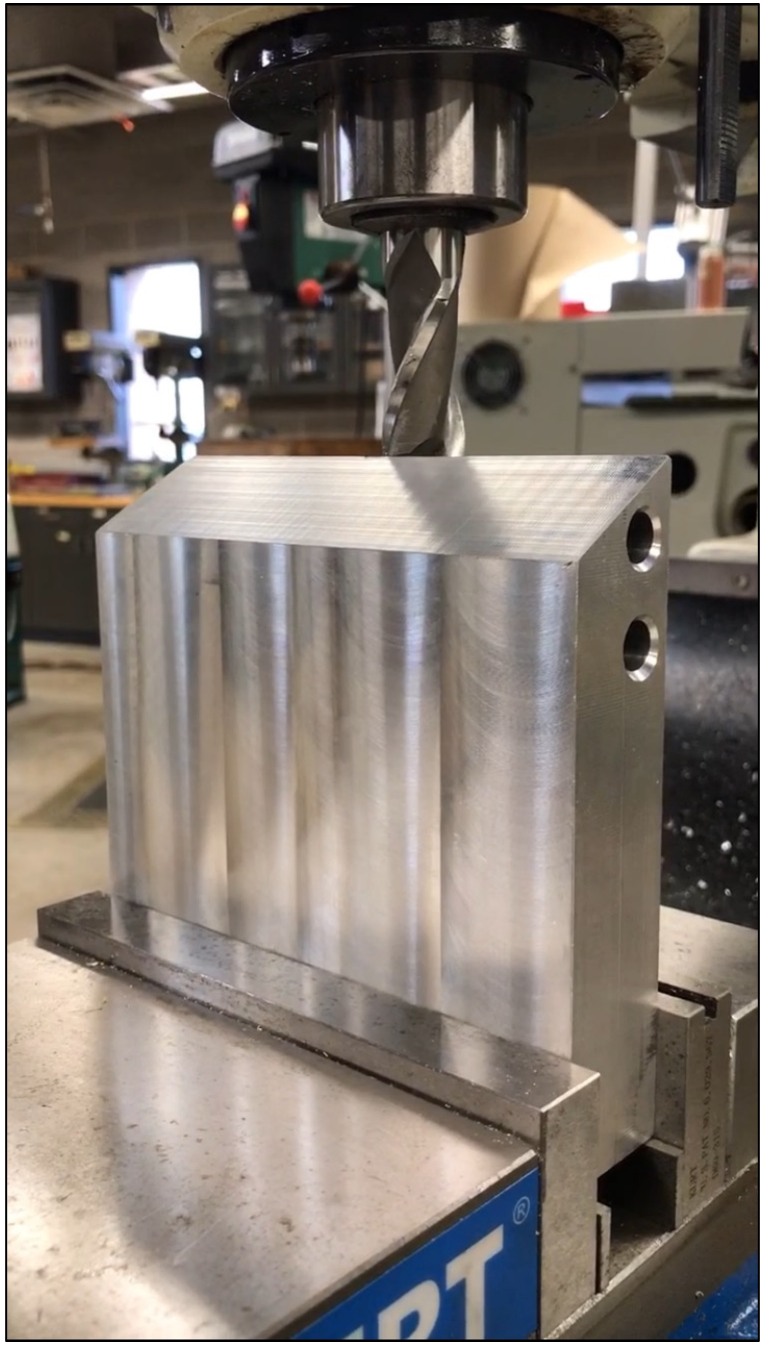
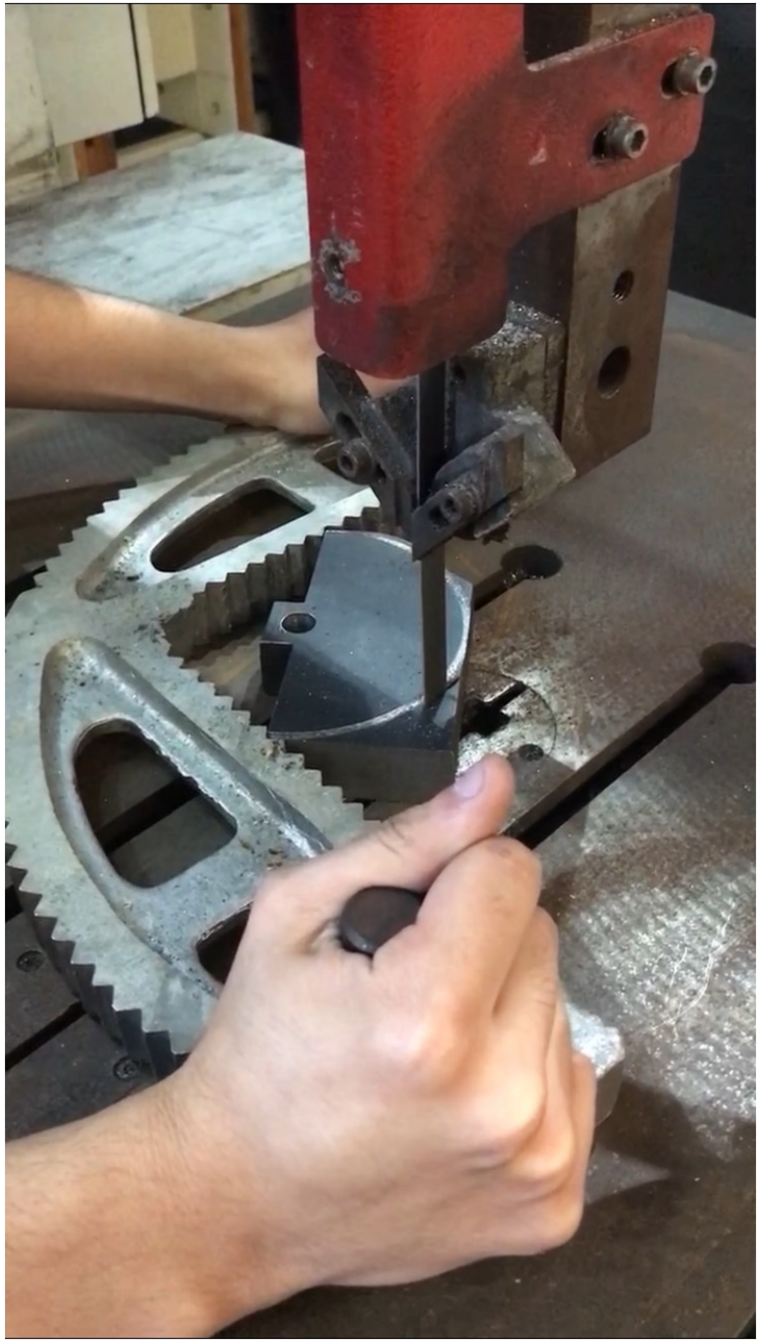

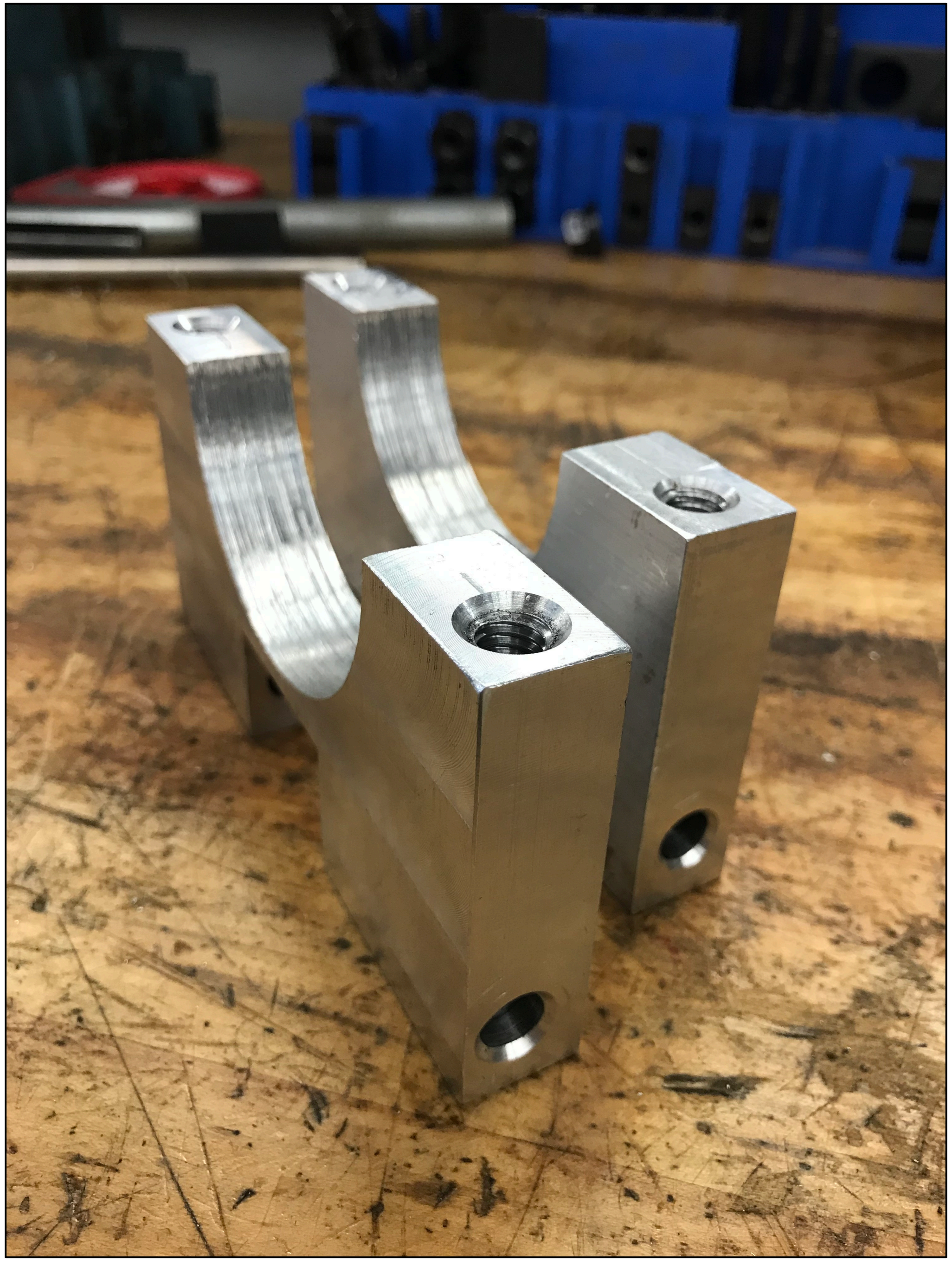
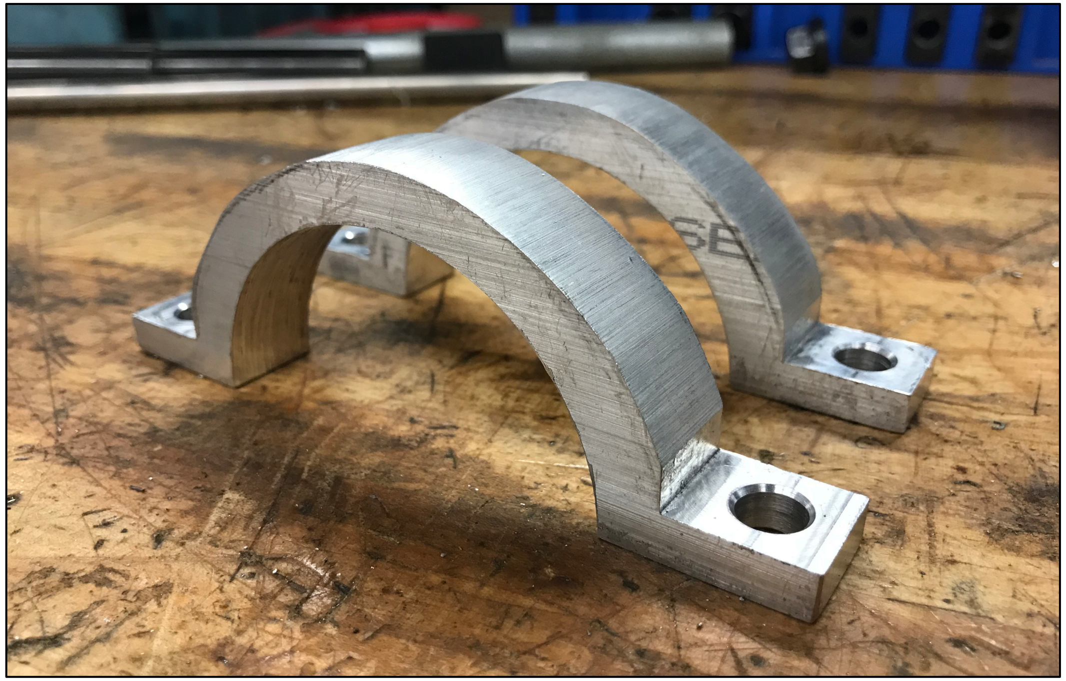
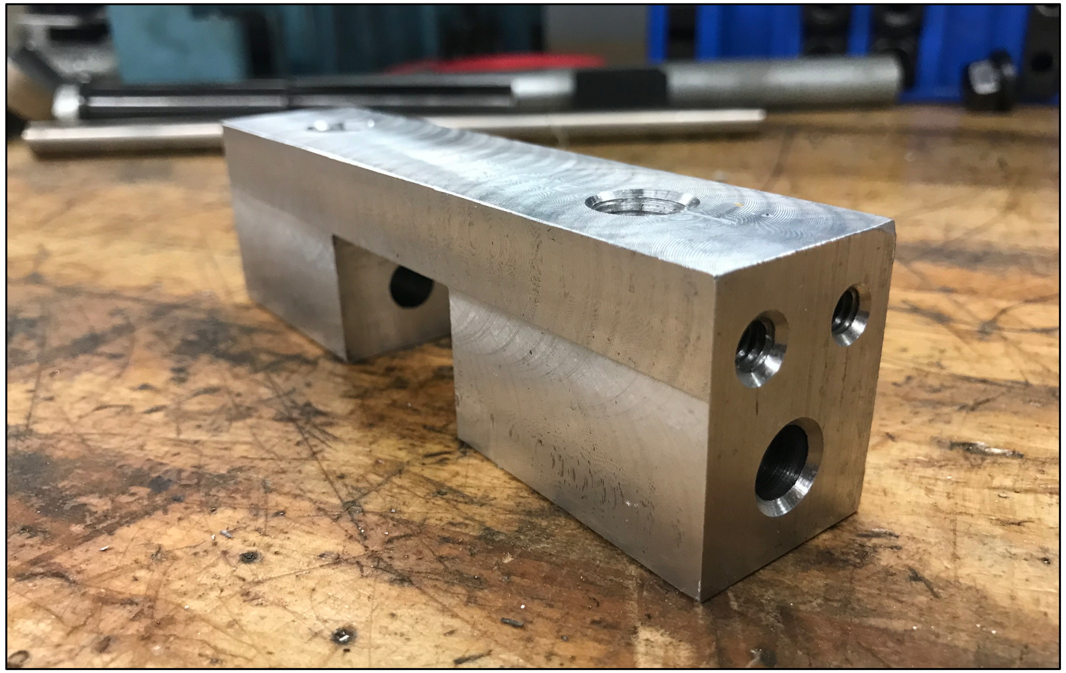


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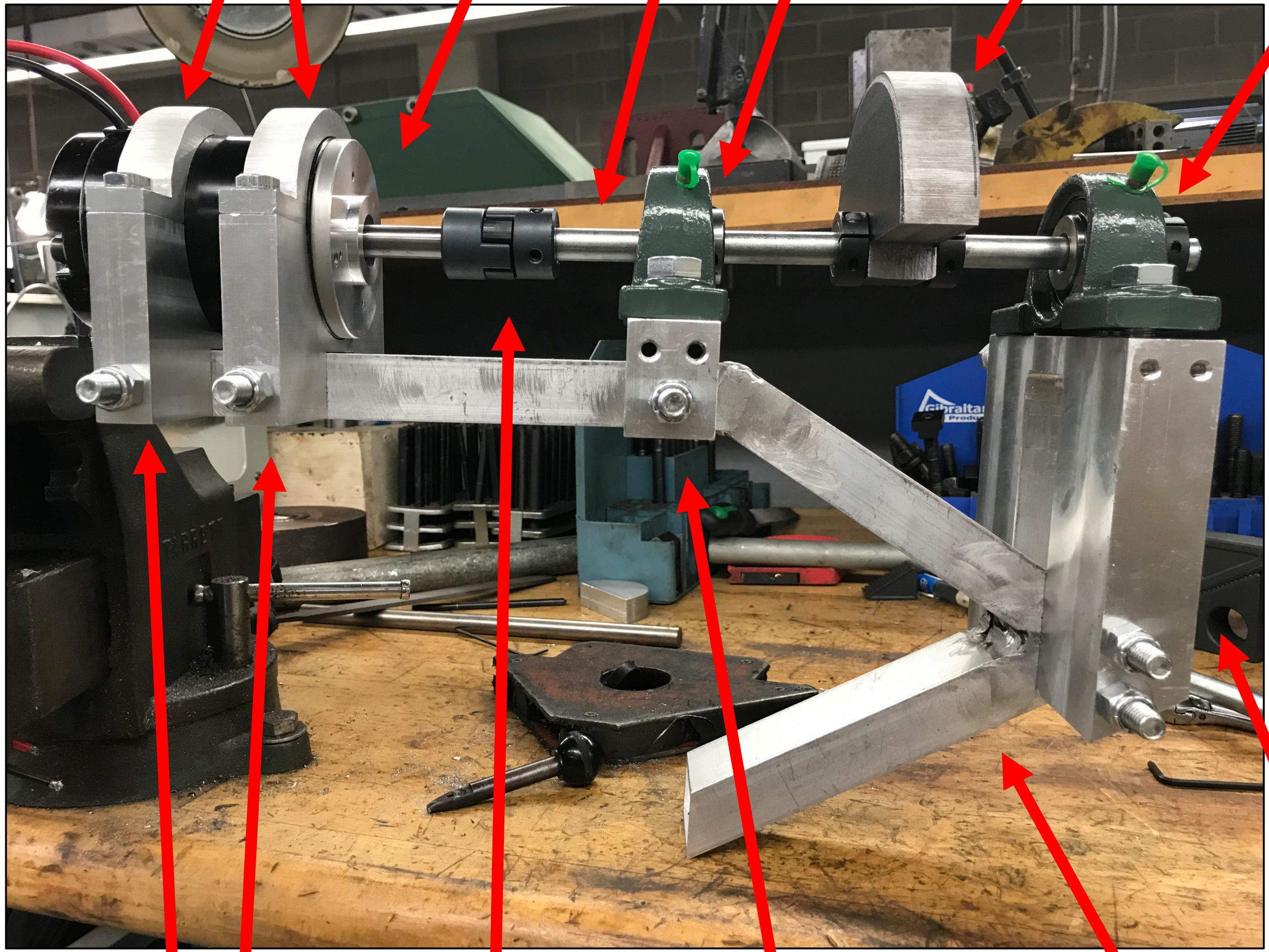
Grizzly

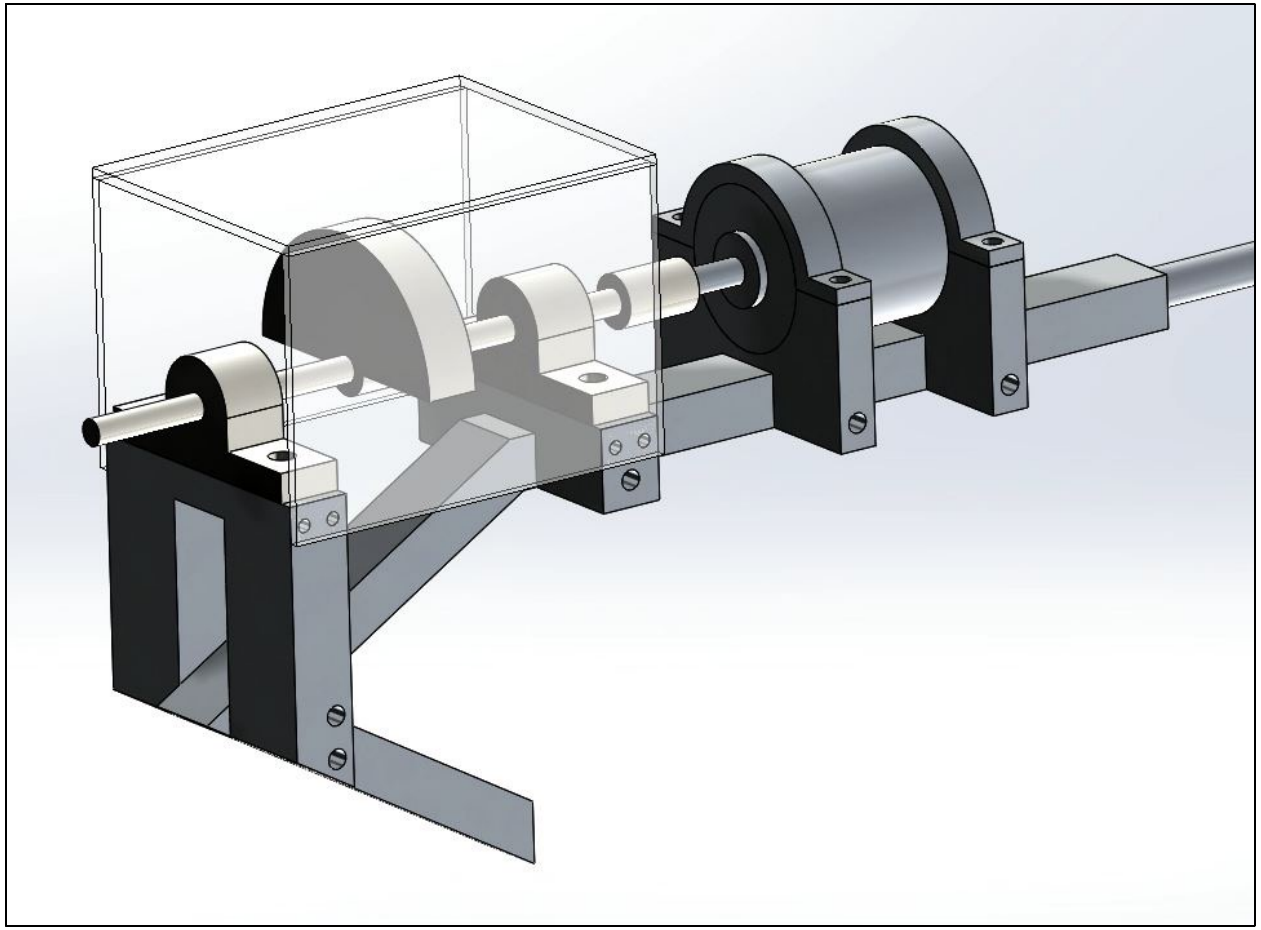


Assembly

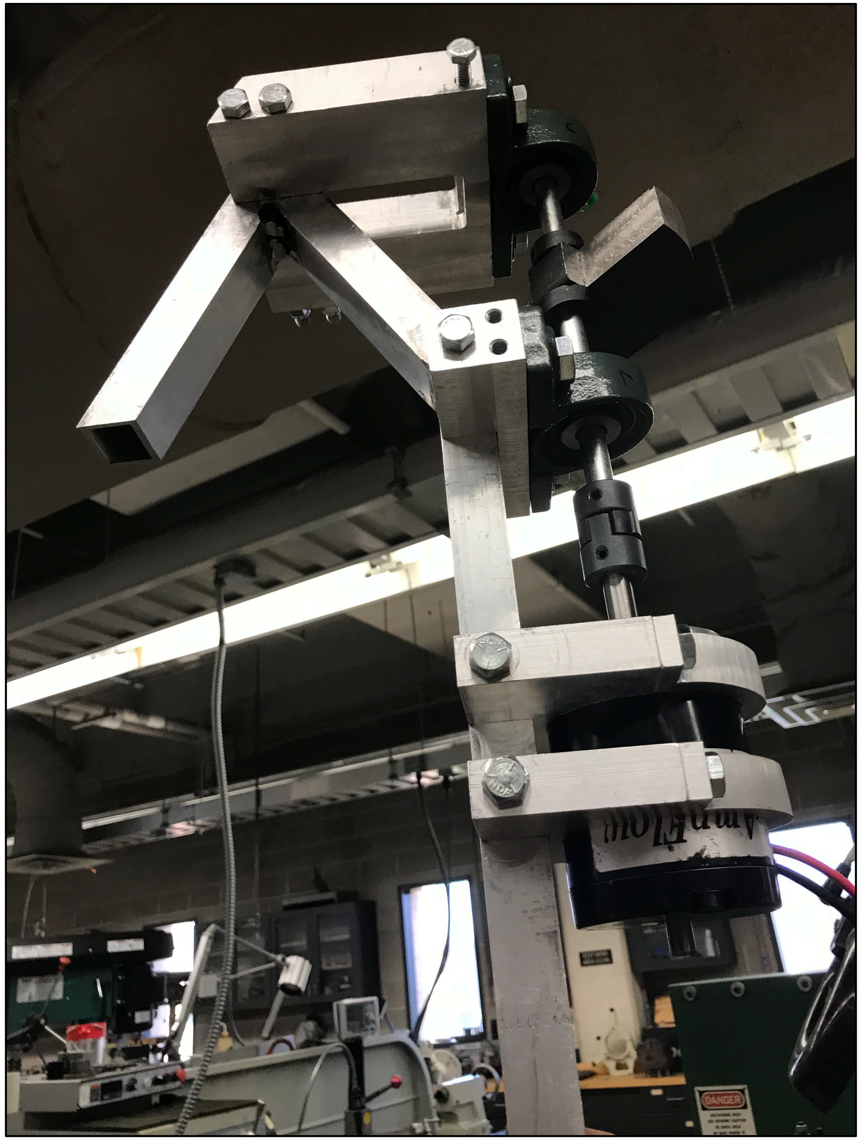
Components

- Motor
- Lower Motor Mount (2x)
- Upper Motor Mount (2x)
- Coupling
- Pillow Block
- Pillow Block Mount (2x)
- Hook Frame
- Shaft
- Offset Mass

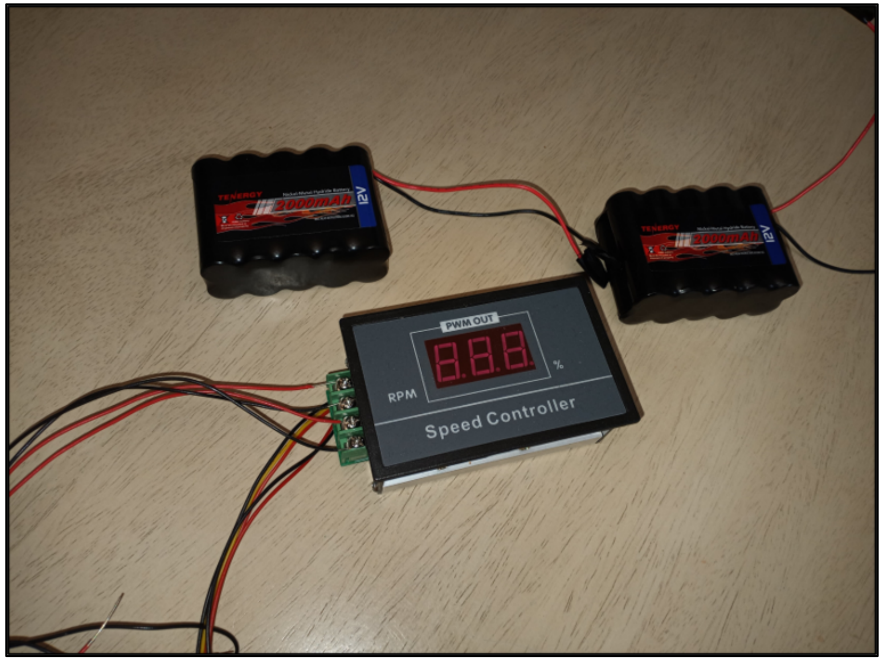
Assembly

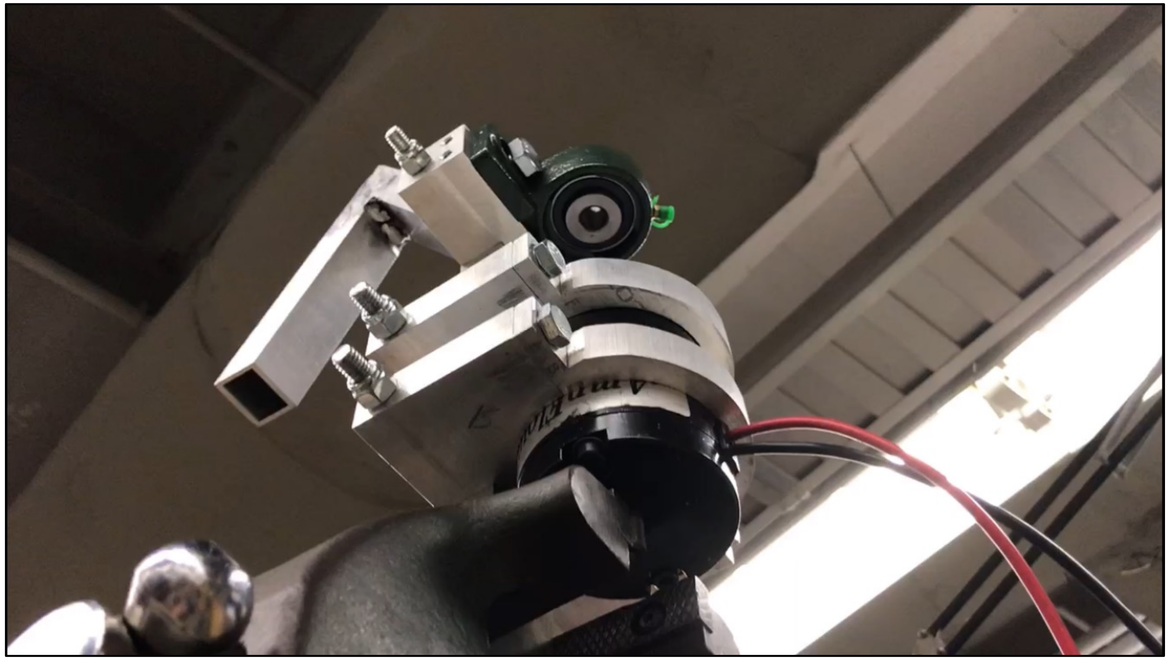


Challenges



- Weight Savings
- Versatility in handling the hook assembly.
- Harvest Season Deadline (before mesquite beans are out of season).





Next Up…

- Mounting Electronic Components (Battery, Speed Controller) onto Assembly.
- Designing and Building Battery Mount.
- Testing on Mesquite Trees.

Calculations

Offset Mass Material : 1020 Steel

1020 steel Density, ρ_{om} = 0.29 lbm / in^3

Offset Mass 1

$\forall$ = 5.83 in^3, m_o = 1.6907 lbm, e = 1.36 in.

$F_o(\omega_{n1}) = (1.6907\ \text{lbm})(1.36/12\ \text{ft})(50.571\ \text{rad/s})^2$

$F_o(\omega_{n1}) = 490.035\ \text{lbm}\cdot\text{ft/s}^2$

NOTE : 1 lbf = 32.2 lbm·ft/s^2

lbm·ft·~~rad^2~~/s^2 → lbm·ft/s^2

→ $F_o(\omega_{n1}) = 15.218\ \text{lbf}$

$F_o(\omega_{n2}) = (1.6907\ \text{lbm})(1.36/12\ \text{ft})(151.079\ \text{rad/s})^2$

$F_o(\omega_{n2}) = 4373.533\ \text{lbm}\cdot\text{ft/s}^2$

→ $F_o(\omega_{n2}) = 135.824\ \text{lbf}$

Offset Mass 2

$\forall$ = 5.98 in^3, m_o = 1.71 lbm, e = 1.39 in.

$F_o(\omega_{n1}) = (1.71\ \text{lbm})(1.39/12)(50.571\ \text{rad/s})^2$

$F_o(\omega_{n1}) = 506.562\ \text{lbm}\cdot\text{ft/s}^2$

→ $F_o(\omega_{n1}) = 15.731\ \text{lbf}$

$F_o(\omega_{n2}) = (1.71\ \text{lbm})(1.39/12)(151.079\ \text{rad/s})^2$

$F_o(\omega_{n2}) = 4521.035\ \text{lbm}\cdot\text{ft/s}^2$

→ $F_o(\omega_{n2}) = 140.405\ \text{lbf}$

Offset Mass 3

$\forall$ = 10.01 in^3, m_o = 2.86 lbm, e = 1.03 in.

$F_o(\omega_{n1}) = (2.86\ \text{lbm})(1.03/12\ \text{ft})(50.571\ \text{rad/s})^2$

$F_o(\omega_{n1}) = 627.805\ \text{lbm}\cdot\text{ft/s}^2$

→ $F_o(\omega_{n1}) = 19.497\ \text{lbf}$

$F_o(\omega_{n2}) = (2.86\ \text{lbm})(1.03/12\ \text{ft})(151.079\ \text{rad/s})^2$

$F_o(\omega_{n2}) = 5603.124\ \text{lbm}\cdot\text{ft/s}^2$

→ $F_o(\omega_{n2}) = 174.010\ \text{lbf}$

Offset Mass 4

$\forall$ = 8.15 in^3, m_o = 2.32 lbm, e = 1.18 in.

$F_o(\omega_{n1}) = (2.32\ \text{lbm})(1.18/12\ \text{ft})(50.571\ \text{rad/s})^2$

$F_o(\omega_{n1}) = 583.434\ \text{lbm}\cdot\text{ft/s}^2$

→ $F_o(\omega_{n1}) = 18.119\ \text{lbf}$

$F_o(\omega_{n2}) = (2.32\ \text{lbm})(1.18/12\ \text{ft})(151.079\ \text{rad/s})^2$

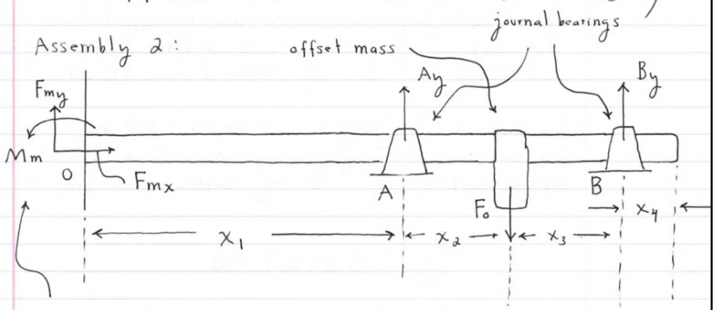
$F_o(\omega_{n2}) = 5207.112\ \text{lbm}\cdot\text{ft/s}^2$

→ $F_o(\omega_{n2}) = 161.712\ \text{lbf}$

Calculations (Contd.)

Pillow Block Forces (Assem. 2)

Assembly 2:

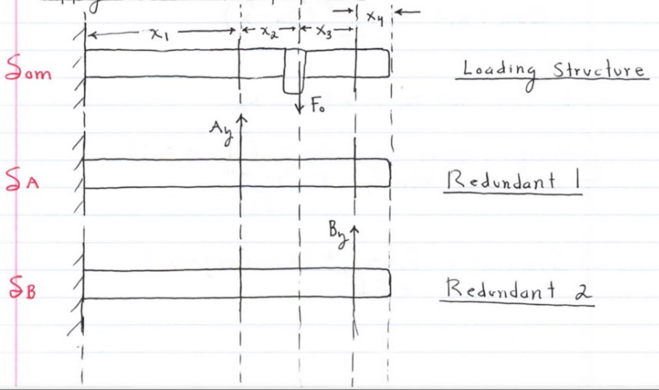


$x_1 = 5\text{in.}, \quad x_2 = 3\text{in}, \quad x_3 = 3\text{in}, \quad x_4 = 1\text{in.}$

for offset mass 3 : $F_o(\omega_{n1}) = 19.497 \text{ lbf}$

\# of Reactions : 5
\# of equilibrium eqns. : 3
} Statically Indeterminate

Apply Method of Superposition



$\delta_{om}(x_1)$: "Deflection at x_1 due to offset Mass Force."
$\delta_A(x_1)$: " " Bearing Vertical Force (Reaction) at A.
$\delta_B(x_1)$: " " Bearing Vertical Force (Reaction) at B.

$\delta_{om}(x_1+x_2+x_3)$: "Deflection at $(x_1+x_2+x_3)$ due to OM Force."
$\delta_A(x_1+x_2+x_3)$: " " Bearing Vertical Force (Reaction) at A.
$\delta_B(x_1+x_2+x_3)$: " " Bearing Vertical Force (Reaction) at B.

$$\text{(eq.1)} \quad \Sigma \delta(x_1) = 0$$

$$\text{(eq.2)} \quad \Sigma \delta(x_1+x_2+x_3) = 0$$

$$\text{(eq.1)} \rightarrow \delta_{om}(x_1) + \delta_A(x_1) + \delta_B(x_1) = 0$$

$$\text{(eq.2)} \rightarrow \delta_{om}(x_1+x_2+x_3) + \delta_A(x_1+x_2+x_3) + \delta_B(x_1+x_2+x_3) = 0$$

(concentrated load at any point)

$$\delta_{om}(x_1) = \frac{Px^2}{6EI}(3a - x)$$

$P = F_o, \quad x = x_1, \quad a = x_1 + x_2$

Circular, Steel Shaft / Rod (d = 0.5in.)
→ $E = \text{"}30\times10^6 \text{ lb/in}^2\text{"}, \quad I = \text{"}\frac{\pi d^4}{64}\text{"}$

$$\delta_{om}(x_1) = \frac{F_o(x_1)^2}{6EI}\left(3(x_1+x_2) - x_1\right)$$

$$\delta_{om}(x_1) = \frac{(-19.497)(5)^2}{6(30\times10^6)\left(\frac{\pi\cdot0.5^4}{64}\right)} \cdot (3(8) - 5)$$

$\text{lbf} \cdot \text{in}^2 \cdot \frac{\text{in}^2}{\text{lbf}} \cdot \frac{1}{\text{in}^4} \cdot \text{in} = \text{in}$ $\qquad \delta_{om}(x_1) = -16.770\times10^{-3} \text{ in.}$

(concentrated load at any pt.)

$$\delta_A(x_1) = \frac{Px^2}{6EI} \cdot (3a - x)$$

$P = A_y, \quad x = x_1, \quad a = x_1, \quad E = \text{" "}, \quad I = \text{" "}$

$$\delta_A(x_1) = \frac{A_y x_1^2}{6EI}(3x_1 - x_1)$$

$$\delta_A(x_1) = \frac{A_y(5)^2}{6(30\times10^6)\left(\frac{\pi\cdot0.5^4}{64}\right)}(3(5) - 5)$$

$$\delta_A(x_1) = (452.707\times10^{-6} \text{ in/lbf}) \cdot A_y$$

(concentrated load at any pt.)

$$\delta_B(x_1) = \frac{Px^2}{6EI}(3a - x)$$

$P = B_y, \quad x = x_1, \quad a = x_1+x_2+x_3, \quad E = \text{" "}, \quad I = \text{" "}$

$$\delta_B(x_1) = \frac{B_y x_1^2}{6EI}\left(3(x_1+x_2+x_3) - x_1\right)$$

$$\delta_B(x_1) = \frac{B_y(5)^2}{6(30\times10^6)\left(\frac{\pi\cdot0.5^4}{64}\right)} \cdot (3(11) - 5)$$

Calculations (Contd.)

$$\delta_B(x_1) = (1.268 \times 10^{-3}\ \text{in/lbf})\ B_y$$

(eq.1) → $$(-16.770 \times 10^{-3}\ \text{in.}) + (452.707 \times 10^{-6}\ \text{in/lbf})\ A_y + (1.268 \times 10^{-3}\ \text{in/lbf})\ B_y = 0$$

(concentrated load at any pt.)

$$\delta_{om}(x_1 + x_2 + x_3) = \frac{Pa^2}{6EI}(3x - a)$$

$P = F_o$, $a = x_1 + x_2$, $x = x_1 + x_2 + x_3$, E = " ", I = " "

$$\delta_{om}(x_1 + x_2 + x_3) = \frac{F_o(x_1 + x_2)^2}{6EI}\left(3(x_1 + x_2 + x_3) - (x_1 + x_2)\right)$$

$$\delta_{om}(x_1 + x_2 + x_3) = \frac{(-19.497)(8)^2}{6(30 \times 10^6)\left(\frac{\pi \cdot 0.5^4}{64}\right)} \cdot (3(11) - (8))$$

$$\delta_{om}(x_1 + x_2 + x_3) = -56.489 \times 10^{-3}\ \text{in.}$$

(concentrated load @ any pt.)

$$\delta_A(x_1 + x_2 + x_3) = \frac{Pa^2}{6EI}(3x - a)$$

$P = A_y$, $a = x_1$, $x = x_1 + x_2 + x_3$, E = " ", I = " "

$$\delta_A(x_1 + x_2 + x_3) = \frac{A_y x_1^2}{6EI}\left(3(x_1 + x_2 + x_3) - x_1\right)$$

$$\delta_A(x_1 + x_2 + x_3) = (1.268 \times 10^{-3}\ \text{in/lbf})\ A_y$$

$$\delta_A(x_1 + x_2 + x_3) = \frac{A_y(5)^2}{6(30 \times 10^6)\left(\frac{\pi \cdot 0.5^4}{64}\right)} \cdot (3(11) - 5)$$

(concentrated load at any pt.)

$$\delta_B(x_1 + x_2 + x_3) = \frac{Px^2}{6EI}(3a - x)$$

$P = B_y$, $x = x_1 + x_2 + x_3$, $a = x_1 + x_2 + x_3$, E = " ", I = " "

$$\delta_B(x_1 + x_2 + x_3) = \frac{B_y(x_1 + x_2 + x_3)^2}{6EI}\left(3(x_1 + x_2 + x_3) - (x_1 + x_2 + x_3)\right)$$

$$\delta_B(x_1 + x_2 + x_3) = \frac{B_y(11)^2}{6(30 \times 10^6)\left(\frac{\pi \cdot 0.5^4}{64}\right)} \cdot (3(11) - 11)$$

$$\delta_B(x_1 + x_2 + x_3) = (4.820 \times 10^{-3}\ \text{in/lbf})\ B_y$$

(eq.2) → $$(-56.489 \times 10^{-3}\ \text{in}) + (1.268 \times 10^{-3}\ \text{in/lbf})\ A_y + (4.820 \times 10^{-3}\ \text{in/lbf})\ B_y = 0$$

$$\begin{bmatrix} (452.707 \times 10^{-6}) & (1.268 \times 10^{-3}) \\ (1.268 \times 10^{-3}) & (4.820 \times 10^{-3}) \end{bmatrix} \begin{bmatrix} A_y \\ B_y \end{bmatrix} = \begin{bmatrix} 16.770 \times 10^{-3} \\ 56.489 \times 10^{-3} \end{bmatrix}$$

→ $A_y = 16.027$ lb, $B_y = 7.503$ lb

$+\uparrow \Sigma F_y = 0$; $F_{my} + A_y + B_y - F_o = 0$

→ $F_{my} = -4.033$ lb

$\circlearrowleft + \Sigma M_o = 0$; $M_m + A_y(x_1) - F_o(x_1 + x_2) + B_y(x_1 + x_2 + x_3) = 0$

→ $M_m = -6.692$ lb in

Questions

Ripple Effect