Pre-Lab 2-2

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1) Pyserial is working

2) (a) Mass calc.

$$V = t\left(L_2 w - \frac{\pi}{4} D_1^4 + \frac{\pi}{4} D_2^4\right)$$

$$M = \rho V \rightarrow M = \rho t\left(L_2 w - \frac{\pi}{4} D_1^4 + \frac{\pi}{4} D_2^4\right)$$

For 6061 Aluminum $\rightarrow \rho = (0.0975\ lb/in^3)$

Pendulum 3:

$$M_3 = \left(0.0975 \frac{lb}{in^3}\right)(0.195 in)\left[(7.65 in \cdot 0.750 in) - \frac{\pi}{4}(0.25 in)^4 + \frac{\pi}{4}(4 in)^4\right]$$

$$M_3 = 3.93172\ lb \rightarrow \boxed{M_3 = 1.7834\ kg}$$

Pendulum 4:

$$M_4 = \left(0.0975 \frac{lb}{in^3}\right)(0.225 in)\left[(7.65 in \cdot 0.750 in) - \frac{\pi}{4}(0.25 in)^4 + \frac{\pi}{4}(4 in)^4\right]$$

$$M_4 = 4.5366\ lb \rightarrow \boxed{M_4 = 2.0578\ kg}$$

(b) Center of Gravity:

$$\bar{x} = \frac{\bar{x}_{bar} m_{bar} + \bar{x}_{disk} m_{disk}}{m_{bar} + m_{disk}}$$

$$\bar{x} = \frac{\frac{L_2}{2}\left(\rho L_2 w t - \frac{\pi}{4} D_1^4 t\right) + \left(L_3 - 0.5 D_2\right)\left(\rho \frac{\pi}{4} D_2^4 t\right)}{M}$$

Pendulum 3:

$$\bar{x}_3 = \frac{\left[\frac{7.65}{2}(0.0975)(7.65)(.75)(0.195) - \frac{\pi}{4}(0.25)^4(0.195)\right] + \left[(11.63 - 2)(0.0975)\frac{\pi}{4}(4^4)(0.195)\right]}{3.93172}$$

$\hookrightarrow \bar{x}_3 = 9.46892\,in \rightarrow$ $\boxed{\bar{x}_3 = 240.511\,mm}$

Pendulum 4

$$\bar{x}_4 = \frac{\left[\frac{7.65}{2}(0.0975)(7.65)(.75)(0.225) - \frac{\pi}{4}(0.25)^4(0.225)\right] + \left[(11.63 - 2)(0.0975)\frac{\pi}{4}(4^4)(0.225)\right]}{4.5366\,lb}$$

$\hookrightarrow$ $\boxed{\bar{x}_4 = 240.511\,mm}$

(c) Bar: $I_{bar} = \frac{1}{12}(M_{Bar})(L_2)^2 + (M_{bar})(\bar{x} - \bar{x}_{bar})^2$

Disk: $I_{disk} = \frac{1}{2}(M_{disk})(0.5D_2)^2 + (M_{disk})(\bar{x} - \bar{x}_{disk})^2$

Pendulum 3:

$$I_{bar_3} = \frac{1}{12}\left[(0.0975)(7.65)(.75)(0.195) - \frac{\pi}{4}(0.25)^4(0.195)\right](7.65)^2$$
$$+\left[(0.0975)(7.65)(.75)(0.195) - \frac{\pi}{4}(0.25)^4(0.195)\right]\left(9.46892 - \frac{7.65}{2}\right)$$

$M_{bar_3} = 0.108486$, $M_{disk_3} = 39.2071$

$I_{bar_3} = 1.14136 \text{ lb-in}^2$

$I_{disk_3} = \frac{1}{2}(45.2389)(4) + 45.2389(0.16108)^2$

$I_{disk_3} = 91.65161 \text{ lb-in}^2$

$\hookrightarrow I_{disk_3} = 91.6516 \text{ lb-in}^2$

$I_3 = 92.793 \text{ lb-in}^2 \rightarrow I_3 = 0.02715 \text{ kg-m}^2$

Pendulum 4

$M_{bar_4} = 0.125176$, $M_{disk_4} = 45.2389$

$I_{4\,bar} = 1.31695 \text{ lb-in}^2$

$I_{4\,disk} = 107.069 \text{ lb-in}^2$

$I_4 = 108.386 \rightarrow I_4 = 0.0317 \text{ kg-m}^2$

3) Pendulum 3

$$T_3 = 2\pi\sqrt{\frac{I_3}{m_3 g\,\bar{x}_3}}$$

$$T_3 = 2\pi\sqrt{\frac{0.02715}{(1.7834)(9.81)(0.2405)}}$$

$\hookrightarrow T_3 = 0.504717 \text{ sec}$

$\hookrightarrow f_3 = 1.98 \text{ Hz}$

Pendulum 4

$$T_4 = 2\pi\sqrt{\frac{0.0317}{(2.0578)(9.81)(0.2405)}}$$

$\hookrightarrow$ $T_4 = 0.50771 \text{ sec}$

$\hookrightarrow$ $f_4 = 1.97 \text{ Hz}$

4) In order to adapt for a compound pendulum, we must use the length from the pivot point to the Center of Gravity instead of just the length from the mass to the pivot point. We must use the second order equation for the compound pendulum below:

$$\ddot{\theta} + \frac{mg\,l_c}{J_o}\sin\theta = 0$$

As a result, the values x dot 2 and x dot 1 will become twice their original value. X 2 and X dot 1 both equal angular velocity. See below for equations for X dot 1 and X dot 2:

$$J\ddot{\theta} + b\dot{\theta} + mgl\sin\theta = 0$$

$$x_1 = \theta \quad , \quad \dot{x}_1 = \dot{\theta} = x_2$$

$$x_2 = \dot{\theta} \quad , \quad \dot{x}_2 = \ddot{\theta}$$

$$\hookrightarrow \dot{x}_2 = \frac{1}{J}\left[-b\dot{\theta} - mgl\sin\theta\right]$$

$$\hookrightarrow \dot{x}_2 = \frac{1}{J}\left[-bx_2 - mgl\sin x_1\right]$$