Lab 2: Real Pulley

IB Physics II Period 6, Petach

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1 Goal

To understand the concepts of rotational mechanics and dynamics.

2 Data

2.1 Part 1

Mass of Pulley (g)	Radius of Pulley (cm)
200	7.00

Table 1: Data on the Pulley used in all of the trials of Part 1

Trial	Time (s)	Distance (cm)	Linear Accel. ($\frac{m}{s^2}$)
1	1.41	72.20	0.726
2	1.58	72.12	0.578
3	1.40	72.25	0.737
4	1.46	72.31	0.678
5	1.53	72.00	0.615

Table 2: Five trials for a 5.71 g falling mass in Part 1

Trial	Time (s)	Distance (cm)	Linear Accel. ($\frac{m}{s^2}$)
1	1.01	71.20	1.40
2	1.06	71.20	1.27

Table 3: Two trials for a 11.02 g falling mass in Part 1

Trial	Time (s)	Distance (cm)	Linear Accel. ($\frac{m}{s^2}$)
1	0.85	71.25	1.97
2	0.80	71.20	2.26

Table 4: Two trials for a 16.50 g falling mass in Part 1

2.2 Part 2

Radius of Pulley (cm)
2.40

Table 5: Data on the Pulley used in all of the trials of Part 2

Trial	**Time (s)**	**Distance (cm)**	α(**rad**$\frac{}{s^2}$)	**a** ($\frac{m}{s^2}$)
1	1.00	80.39	53.23	1.61
2	1.00	78.93	49.74	1.58
3	1.00	79.90	50.62	1.60
4	1.00	80.21	53.23	1.60
5	0.95	80.15	51.49	1.78

Table 6: Five trials for a falling mass in Part 2

3 Analysis

3.1 Part 1

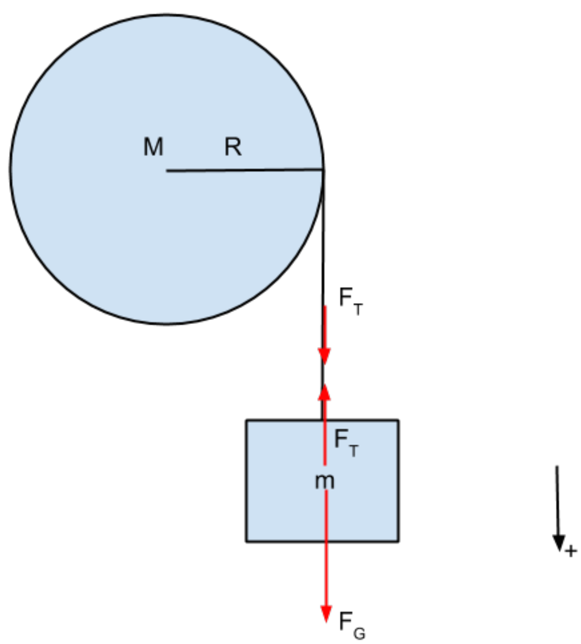

Figure 1: Free Body Diagram of apparatus setup in Part 1

Conducting the sum of forces and torques based on Figure 1:

$$\Sigma F = F_G - F_T = ma$$
$$F_T = F_G - ma = m(g - a)$$

1. Given that $\alpha = \frac{a}{r}$ We will use the data from Table 1 and Table 2 where $m = 5.71$g to calculate α. To find a, we will average the five a values in Table 2:

$$a = \frac{0.726 + 0.578 + 0.737 + 0.678 + 0.615}{5} = 0.667\frac{m}{s^2}$$
$$\alpha = \frac{0.667}{0.07} = \boxed{9.53\frac{rad}{s^2}}$$

The α value for $m = 11.02$g is calculated in the same way:

$$a = \frac{1.40 + 1.27}{2} = 1.34\frac{m}{s^2}$$
$$\alpha = \frac{1.34}{0.07} = \boxed{19.1\frac{rad}{s^2}}$$

The α value for $m = 16.50$g is calculated in the same way:

$$a = \frac{1.97 + 2.26}{2} = 2.12\frac{m}{s^2}$$
$$\alpha = \frac{2.12}{0.07} = \boxed{30.3\frac{rad}{s^2}}$$

2. From above, it was found that $F_T = m(g - a)$. We can plug the values from the different masses and accelerations into this equation to find F_T:
For $m = 5.71$g:

$$F_T = 0.00571(9.8 - 0.667) = \boxed{0.0521N}$$

For $m = 11.02$g:

$$F_T = 0.01102(9.8 - 1.34) = \boxed{0.0932N}$$

For $m = 16.50$g:

$$F_T = 0.0165(9.8 - 2.12) = \boxed{0.127N}$$

3. Using Newton's second law for torques, we can find I_{expt}:

$$I_{expt} = \frac{F_T R}{\alpha}$$

For $m = 5.71$g:

$$I_{expt} = \frac{0.0521 * 0.07}{9.53} = 3.8 * 10^{-4}$$

For $m = 11.02$g:

$$I_{expt} = \frac{0.0932 * 0.07}{19.1} = 3.4 * 10^{-4}$$

For $m = 16.50$g:

$$I_{expt} = \frac{0.127 * 0.07}{30.3} = 2.9 * 10^{-4}$$

Averaging the I_{expt} values from the three masses, the I_{expt} of the pulley is $\boxed{3.4 * 10^{-4} kg * m^2}$

4. From the data in Table 1:

$$I_{calc} = 0.5 * 0.200 * (0.07)^2 = \boxed{4.9 * 10^{-4} kg * m^2}$$

5. Frictional torque was not taken into consideration.

6. The frictional torque is $F_{fr}R$, and it can be calculated from the following equation:

$$\tau_{fr} = I_{calc}\alpha - F_T R$$

For $m = 5.71$g:

$$\tau_{fr} = 4.9 * 10^{-4} * 9.53 - 0.0521 * 0.07 = \boxed{0.0010 N * m}$$

For $m = 11.02$g:

$$\tau_{fr} = 4.9 * 10^{-4} * 19.1 - 0.0932 * 0.07 = \boxed{0.0028 N * m}$$

For $m = 16.50$g:

$$\tau_{fr} = 4.9 * 10^{-4} * 30.3 - 0.127 * 0.07 = \boxed{0.0060 N * m}$$

7. Sources of error in calculating frictional torque may have included imprecise measurements. For example, when measuring the time it took for the mass to fall a certain distance, the exact start and stop times on the stopwatch may not have corresponded with the actual times. In addition, when measuring the distance that the mass fell, the measurement device we were using (a meter stick) may not have been perfectly perpendicular to the surface we were measuring on.

3.2 Part 2

We can find α from the equation $\alpha = \frac{a}{r}$. Therefore we need to first average the a values:

$$a = \frac{1.61 + 1.58 + 1.60 + 1.60 + 1.78}{5} = 1.634$$

$$\alpha_{calc} = \frac{a}{r} = \frac{1.634}{.0240} = 68.1 \frac{rad}{s^2}$$

The average measured α value from the RoMo sensor was $51.67 \frac{rad}{s^2}$

The percent error is:

$$\frac{|68.1 - 51.67|}{51.67} * 100 = \boxed{31.8\%}$$