

Rotational Motion

Open-ended Lab

Purpose:

1. Determine the acceleration of a block when released from a pulley system.
2. Using the relationship between linear and rotational acceleration, determine the rotational inertia of the pulley.

Materials: Pulley with a block as illustrated to the left. Motion detector below the mass to measure linear acceleration by collecting distance vs. time data.

Procedure:

A pulley of unknown mass will be used in the lab experiment, as shown above. A small mass of 51.5 *g* is attached to a string; the other end is attached to the pulley and wrapped around it several times. The block is released from rest, and distance vs. time data is collected with a motion detector CBL unit.

Data:

The time *t* is measured for various heights *D* and the data are recorded in the following table.

|  |  |  |
| --- | --- | --- |
| Moment of Inertia of a Pulley | | |
|  |  |  |
| Time (s) | Time^2 (s^2) | Distance (m) |
| 0.28 | 0.0784 | 0.380947 |
| 0.288 | 0.082944 | 0.371507 |
| 0.296 | 0.087616 | 0.360956 |
| 0.304 | 0.092416 | 0.350127 |
| 0.312 | 0.097344 | 0.338466 |
| 0.32 | 0.1024 | 0.326804 |
| 0.328 | 0.107584 | 0.314032 |
| 0.336 | 0.112896 | 0.301259 |
| 0.344 | 0.118336 | 0.287932 |
| 0.352 | 0.123904 | 0.273494 |
| 0.36 | 0.1296 | 0.2585 |
| 0.368 | 0.135424 | 0.243506 |
| 0.376 | 0.141376 | 0.227958 |
| 0.384 | 0.147456 | 0.211576 |
| 0.392 | 0.153664 | 0.195194 |
| 0.4 | 0.16 | 0.178257 |
| 0.408 | 0.166464 | 0.163263 |
| 0.416 | 0.173056 | 0.142716 |
| 0.424 | 0.179776 | 0.125224 |

Data Analysis:

What quantities should be graphed in order to best determine the acceleration of the block? Explain your reasoning.

The distance versus the time squared should be graphed and a best-fit curve found. This is based off of the formula, Δy = vit + ½ at2. There is no initial velocity, so that term goes to zero, leaving the equation Δy = ½ at2 which means that the slope of the curve is equal to ½ a. In order to determine the acceleration, the slope is multiplied by 2.

1. Plot the quantities determined in (1), title the graph, label the axes, and calculate the linear acceleration of the block. Use this acceleration and Newton’s second law for linear motion to find the tension in the string.

a = 2(slope) = 2(-2.5358) = -5.07 m/s2

T = mg - ma = 0.0515 kg(9.81 m/s2) - 0.0515 kg(5.07 m/s2) = 0.244 N

1. Derive an expression for the relationship between the linear acceleration of the block and the angular acceleration of the pulley and the tension in the string.

ablock = atan = aang(r)

Στ = I(aang)

T(r) = I(aang)

T(r)/( atan/r) = I

T(r)2/atan = I

1. Calculate the rotational inertia of the pulley.

I = 0.244 N(0.0365m)2/(5.07 m/s2) = 6.41 x 10-5 kg\*m2

1. Is your answer reasonable? Why or why not?

This answer is reasonable because it is a very small value. There is very little resistance to movement (or inertia) with this pulley, due to the fact that the mass fell very quickly. Therefore, a small moment of inertia value is reasonable.