Massive Pulley Atwood Machine Lab

Pulley mass and the acceleration of hanging masses

Name _____ Period _____ Date _____

Compare the two rope tensions, then investigate how pulley mass affects acceleration. Linearize the results and use the graph to determine g.

Time 50 minutes • Open buildphysics.com/?experiment=massive-pulley-atwood

Model and measurements

The string does not slip on the solid-disk pulley. Keep hanging masses at 3.0 kg on the left and 1.0 kg on the right; g = 9.8 m/s².

$$\Sigma F = ma \quad \Sigma\tau = I\alpha \quad a = \alpha R$$

m_1 is left mass, m_2 is right mass, and M is pulley mass. Acceleration magnitude a is positive while the left mass moves downward.

Predict before running

Will a heavier pulley make the hanging masses accelerate faster or more slowly? Predict and explain.

Part A Compare pulley masses

1. In Explore this setup, set Left hanging mass to 3.0 kg and Right hanging mass to 1.0 kg. Test the Pulley masses below. Reset between trials.
2. Run to 0.20 s using Auto-pause after (clock beside Run) or Step. In Properties → Heavier mass → Live values, read acceleration magnitude |a|.
3. Turn on Tension and read the force-arrow magnitudes on both hanging masses.

Pulley M (kg)	a (m/s²)	Left tension (N)	Right tension (N)
0.5			
3.0			
6.0			

A1. Use two trials to compare pulley mass and acceleration. Which tension was larger?

A2. Explain why unequal tensions are needed to accelerate the massive pulley angularly.

Part B Design and collect

Suggested time 16 minutes

Investigation question How does the mass of a solid-disk pulley affect system acceleration?

Choose at least five pulley masses from 0.5 to 6.0 kg, spread across the range. Keep both hanging masses and the pulley radius unchanged.

B1. Identify the independent and dependent variables.

B2. What will you keep constant? How will you do this?

B3. List your pulley masses. Why is this set useful?

B4. How will you measure acceleration during free motion before either mass reaches the pulley?

B5. Write a procedure another group could follow.

Record your measurements

Left m_1 = 3.0 kg Right m_2 = 1.0 kg Solid-disk pulley

Trial	Pulley M (kg)	Acceleration a (m/s²)
1		
2		
3		
4		
5		
Extra		

Part C Build and analyze a linear graph

Suggested time 14 minutes

C1. The relationship is $a = \frac{(m_1 - m_2)g}{m_1 + m_2 + \frac{M}{2}}$. Describe how a depends on pulley mass M when the hanging masses stay fixed.

C2. Choose quantities for a straight-line graph. Label the table with your choices and units, and calculate the transformed values.

Trial	_____ Units _____	_____ Units _____
1		
2		
3		
4		
5		
Extra		

C3. Plot your transformed data and draw a best-fit line. Label both axes with quantities and units.



C4. Find slope and units using two separated points on your fitted line. Use the fit to determine g. Interpret the intercept.

Part D Explain and predict

Suggested time 8 minutes

D1. A student claims, “The tension must be equal on both sides because it is one string.” Evaluate this claim using Part A.

D2. Does your graph support the massive-pulley model? Compare inferred g with 9.8 m/s² and explain the intercept.

D3. Choose an unused pulley mass within your measured range. Predict a from your fit before running. Measure acceleration at 0.20 s and compare.

New M (kg)	Predicted a (m/s²)	Measured a (m/s²)

Comparison