



Introduction to Mechanics

The Atwood Machine

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Last time

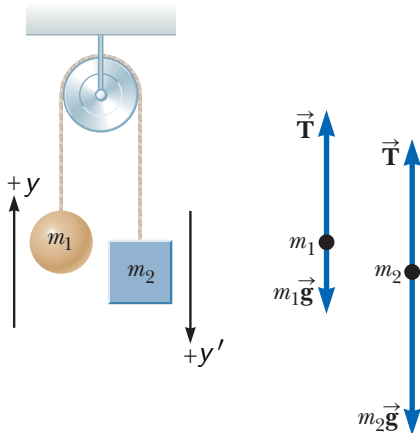
- objects accelerated together
- introduced the Atwood machine

Overview

- the Atwood machine, and variants
- introduce friction

Pulleys and the Atwood Machine

The Atwood Machine can be used to make careful determinations of g , as well as explore the behavior of forces and accelerations.



Pulleys and the Atwood Machine

We can consider the motion for each mass separately.

mass 1, y-direction:

$$\begin{aligned} F_{\text{net},1y} &= m_1 a_y \\ T - m_1 g &= m_1 a \end{aligned} \tag{1}$$

mass 2, y'-direction:

$$\begin{aligned} F_{\text{net},2y'} &= m_2 a_{y'} \\ m_2 g - T &= m_2 a \end{aligned} \tag{2}$$

Pulleys and the Atwood Machine

We can consider the motion for each mass separately.

mass 1, y-direction:

$$\begin{aligned} F_{\text{net},1y} &= m_1 a_y \\ T - m_1 g &= m_1 a \end{aligned} \quad (1)$$

mass 2, y'-direction:

$$\begin{aligned} F_{\text{net},2y'} &= m_2 a_{y'} \\ m_2 g - T &= m_2 a \end{aligned} \quad (2)$$

Be careful about the signs! Both masses must accelerate together - one up, one down.

Two equations, two unknowns. Solve as you like!

Pulleys and the Atwood Machine

$$T - m_1g = m_1a \quad (1)$$

$$m_2g - T = m_2a \quad (2)$$

Take eq (1) + eq (2):

$$\begin{aligned} m_2g - m_1g &= m_1a + m_2a \\ a &= \frac{(m_2 - m_1)g}{m_1 + m_2} \end{aligned}$$

Pulleys and the Atwood Machine

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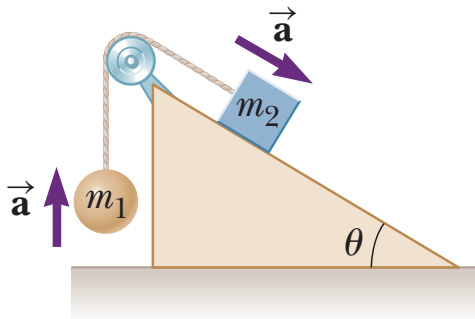
Putting a into either eq (1) or eq (2):

$$T = \frac{2m_1m_2g}{m_1 + m_2}$$

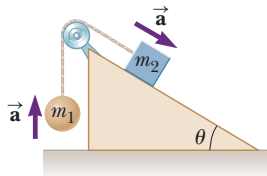
Pulley with an Incline

Let's change up our Atwood machine apparatus so that one of the masses is on a slanted surface with no friction. Assume $m_2 \sin \theta > m_1$, so the blocks slide as shown.

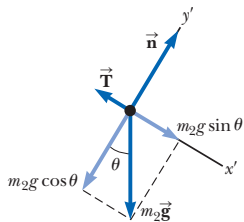
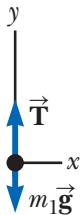
Try to solve this one yourself! $a = ?$, $T = ?$



Pulley with an Incline



We can still consider each object separately:



Acceleration? Tension?

Pulley with an Incline

We must have $a_y = a_{x'} = a$.

Pulley with an Incline

We must have $a_y = a_{x'} = a$.

Object 1:

x-direction: no forces w/ components in $x \Rightarrow F_{\text{net},x} = 0, a_x = 0$.

y-direction:

$$\begin{aligned} F_{\text{net},y} &= m_1 a_y \\ T - m_1 g &= m_1 a \end{aligned} \tag{3}$$

Pulley with an Incline

We must have $a_y = a_{x'} = a$.

Object 1:

x-direction: no forces w/ components in $x \Rightarrow F_{\text{net},x} = 0, a_x = 0$.

y-direction:

$$\begin{aligned} F_{\text{net},y} &= m_1 a_y \\ T - m_1 g &= m_1 a \end{aligned} \quad (3)$$

Object 2:

x' -direction:

$$\begin{aligned} F_{\text{net},x'} &= m_2 a_{x'} \\ m_2 g \sin \theta - T &= m_2 a \end{aligned} \quad (4)$$

y' -direction: $a_{y'} = 0$.

Pulley with an Incline

Two masses are connected by a string that passes over a pulley. One mass is on an inclined plane and the other is hanging vertically. The pulley is frictionless and the string is massless.

The mass on the incline is m_1 and the mass hanging vertically is m_2 . The incline makes an angle θ with the horizontal.

The forces acting on the mass on the incline are the normal force N , the weight $m_1 g$, and the tension T in the string.

The forces acting on the hanging mass are the weight $m_2 g$ and the tension T in the string.

The acceleration of the system is a .

The tension in the string is T .

The normal force is N .

The weight of the mass on the incline is $m_1 g$.

The weight of the hanging mass is $m_2 g$.

The angle of the incline is θ .

The pulley is frictionless.

The string is massless.

Summary

- the Atwood machine, and variants
- introduce friction (?)

Homework

Walker Physics:

- Ch 6, Problems: 43, 45, 47 (Atwood-type)
- Ch 6, onwards from page 177. Questions: 3, 15; Problems: 1, 3, 7, 11, 13, 15, 87 (friction)