Introduction to Mechanics
The Atwood Machine

Lana Sheridan

De Anza College

March 9, 2020

Last time

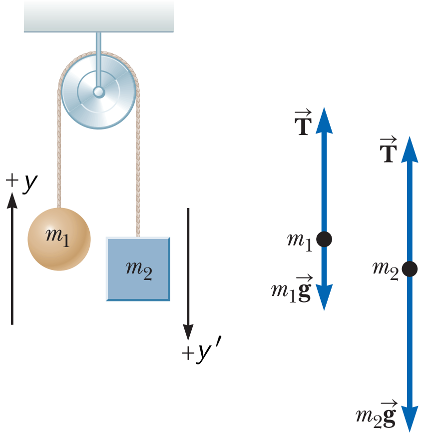
- objects accelerated together
- introduced the Atwood machine

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.



[1] http://en.wikipedia.org/wiki/Atwood_machine

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:

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

mass 2, y'-direction:

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

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

$$T - m_1 g = m_1 a \quad (1)$$

$$m_2 g - T = m_2 a \quad (2)$$

Take eq (1) + eq (2):

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

Pulleys and the Atwood Machine

$$T - m_1 g = m_1 a \quad (1)$$

$$m_2 g - T = m_2 a \quad (2)$$

Take eq (1) + eq (2):

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

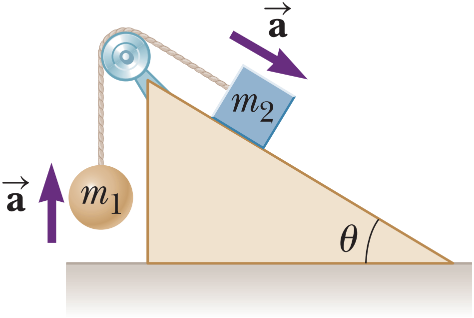
Putting a into either eq (1) or eq (2):

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

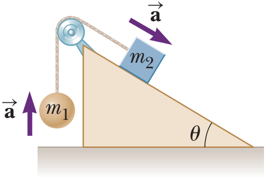
Pulley with an Incline

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.

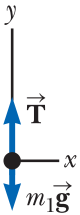
Try to solve this one yourself! $a = ?,\ T = ?$

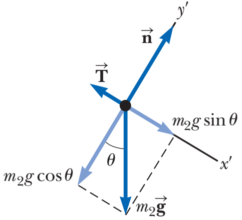


Pulley with an Incline



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

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

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:

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

Object 2:

x'-direction:

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

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

Pulley with an Incline

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)