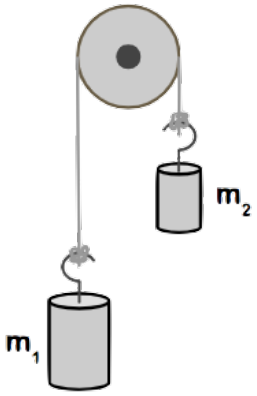
How to Solve an Atwood's Machine Problem

Lesson Notes

Learning Outcomes

- How do you use a free-body diagram and Newton's second law to analyze and solve an Atwood's Machine problem?



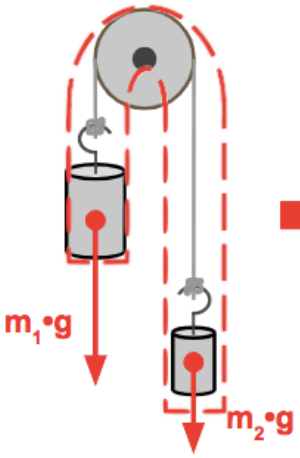
The Basic Approach to Solving a Two-Body Problem

The solution to any two-body problem (including Atwood's Machine problems) will typically include two analyses:

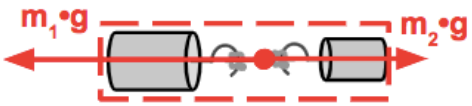
- **A System Analysis**:
  Used to determine the acceleration
- **An Individual Object Analysis**:
  Used to determine an "internal force"

Straightening the System

Because of the pulley, the system has a highly irregular (or at least, uncomfortable) shape.



The system is commonly straightened out and pictured with competing gravity forces pulling in opposite directions.

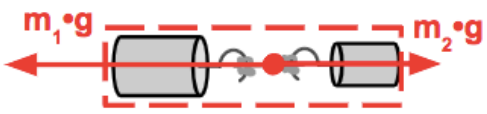


Example 1

A 5.0-kg and 10.0-kg mass are attached by a string that is stretched around a pulley. Determine the acceleration of the objects and the tension in the string.

Step 1: System Analysis

m_{total} = 15.0 kg

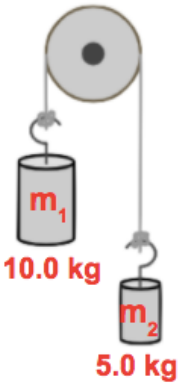


$F_{net} = m_1 \cdot g - m_2 \cdot g$

F_{net} = (10.0 kg)•(9.8 N/kg) - (5.0 kg)•(9.8 N/kg)

F_{net} = 49.0 N

$a = F_{net} / m$ = 49.0 N /15.0 kg = **3.27 m/s/s**



Step 2: Individual Object Analysis

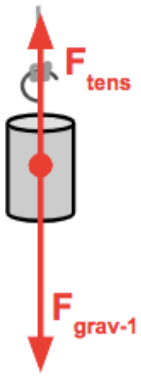
Consider $\mathbf{m_1}$: $m_1 = 10.0\ kg$

$F_{grav-1} = m_1 \cdot g = (10.0\ kg) \cdot (9.8\ N/kg)$

$F_{grav-1} = 98.0\ N$

$F_{net} = m_1 \cdot a = (10.0\ kg) \cdot (3.2666\ldots\ m/s/s)$

$F_{net} = 32.7\ N$



$F_{net} = F_{grav-1} - F_{tens}$

$32.7\ N = 98.0\ N - F_{tens}$

$F_{tens} = 98.0\ N - 32.7\ N$

$\mathbf{F_{tens} = 65.3\ N}$

($F_{tens} = 65.33333\ldots N$)

It doesn't matter which object is used for the Individual Object Analysis. The resulting calculation of tension will end up yielding the same value:

Step 2: Individual Object Analysis

Consider $\mathbf{m_2}$: $m_2 = 5.0\ kg$

$F_{grav-2} = m_2 \cdot g = (5.0\ kg) \cdot (9.8\ N/kg)$

$F_{grav-2} = 49.0\ N$

$F_{net} = m_2 \cdot a = (5.0\ kg) \cdot (3.2666\ldots\ m/s/s)$

$F_{net} = 16.3\ N$

$F_{net} = F_{tens} - F_{grav-2}$

$16.3\ N = F_{tens} - 49.0\ N$

$F_{tens} = 16.3\ N + 49.0\ N$

$\mathbf{F_{tens} = 65.3\ N}$

($F_{tens} = 65.33333\ldots N$)