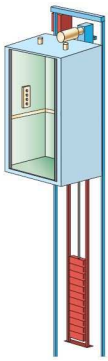
# SPH4U UNIVERSITY PHYSICS

DYNAMICS

- Atwood's Machine & Fletcher's Trolley (P.~)

## Connected Objects

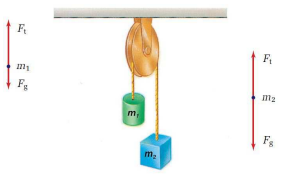
*Elevators are not simply suspended from cables. Instead, the supporting cable passes up over a pulley and then back down to a heavy, movable* ***counterweight****, as shown. Gravitational forces acting downward on the counterweight create tension in the cable. The cable then exerts an upward force on the elevator cage. Most of the weight of the elevator and passengers is balanced by the counterweight. Only relatively small additional forces from the elevator motors are needed to raise and lower the elevator and its counterweight.*





## Connected Objects

*Elevators are only one of many examples of machines that have large masses connected by a cable that runs over a pulley. In fact, in 1784, mathematician George Atwood built a machine similar to the simplified illustration shown below. He used his machine to test and demonstrate the laws of uniformly accelerated motion and to determine the value of "g". The acceleration of Atwood's machine depended on "g", but was small enough to measure accurately.*

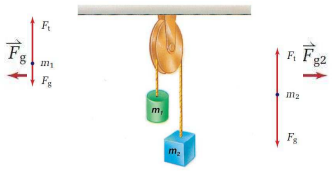


## Activity: Atwood's Machine & Fletcher's Trolley

**INSTRUCTIONS**

A. Working with a partner, derive a formula to determine the acceleration due to gravity "**g**" using an Atwood machine. Assume $m_1 > m_2$

Hint? "Two hanging masses" problem.



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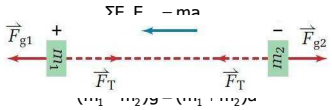



$$g = \frac{(m_1 + m_2)}{(m_1 - m_2)} a$$



## Activity: Atwood's Machine & Fletcher's Trolley

**INSTRUCTIONS**

B. Watch the following "Atwood" video. Be sure to record the masses, distance, and times.

$m_1$ = 560 g
$m_2$ = 550 g
d = 1.0 m
t1 = 4.82 s
t2 = 4.79 s

## Activity: Atwood's Machine & Fletcher's Trolley

**INSTRUCTIONS**

C. Use distance and average time to find the acceleration of the masses.

$m_1$ = 560 g
$m_2$ = 550 g
d = 1.0 m
t1 = 4.82 s
t2 = 4.79 s

$t_{avg}$ = 4.805 s ☜ a = 0.08662 m/s$^2$



## Activity: Atwood's Machine & Fletcher's Trolley

**INSTRUCTIONS**

D. Use your "Atwood" formula to determine the acceleration due to gravity "**g**". Let $m_1$ be the larger mass.

$m_1$ = 560 g
$m_2$ = 550 g
d = 1.0 m
t1 = 4.82 s
t2 = 4.79 s

$$g = \frac{(m_1 + m_2)}{(m_1 - m_2)} a$$

$t_{avg}$ = 4.805 s ☜ a = 0.08662 m/s$^2$

g = 9.62 m/s$^2$

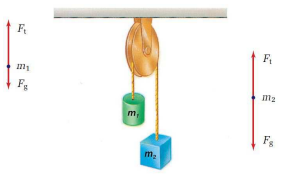


## Atwood's Machine & Fletcher's Trolley – Activity

**QUESTIONS**

1. Rearrange your Atwood formula to calculate the acceleration "**a**" of the hanging objects.

$$a = \frac{(m_1 - m_2)}{(m_1 + m_2)} g$$

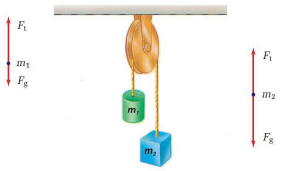


## Activity: Atwood's Machine & Fletcher's Trolley

**QUESTIONS**

2. Under what circumstances would the acceleration of the Atwood machine be zero?

   both objects have the same mass



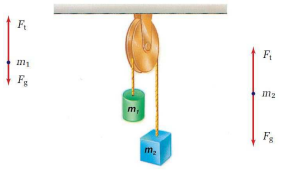



## Activity: Atwood's Machine & Fletcher's Trolley

**QUESTIONS**

3. What combination of masses would make the acceleration of an Atwood machine equal to ½g? (Hint: use a = ½g or g = 2a)

   $m_1 = 3m_2$



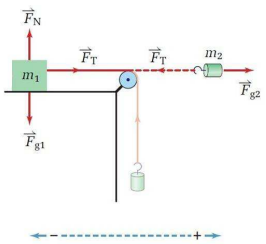



## Activity: Atwood's Machine & Fletcher's Trolley

**QUESTIONS**

4. Derive a similar formula for the acceleration of a Fletcher's trolley apparatus (i.e. a single hanging mass)? Assume that friction is negligible and that object 2 is the hanging mass.

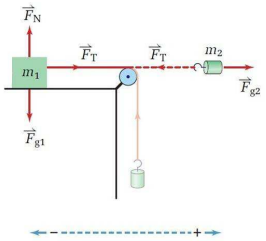
$$a = \frac{m_2 g}{m_1 + m_2}$$



## Activity: Atwood's Machine & Fletcher's Trolley

**QUESTIONS**

5. If you wanted to calculate the acceleration due to gravity using a Fletcher's trolley, what would the formula look like? Again, assume that friction is negligible and that object 2 is the hanging mass.




$$g = \frac{(m_1 + m_2)\,a}{m_2}$$



## ✔ Check Your Learning

**WIKI (DYNAMICS)**

- 4U1 - WS#3 (The Bricklayer's Tale)