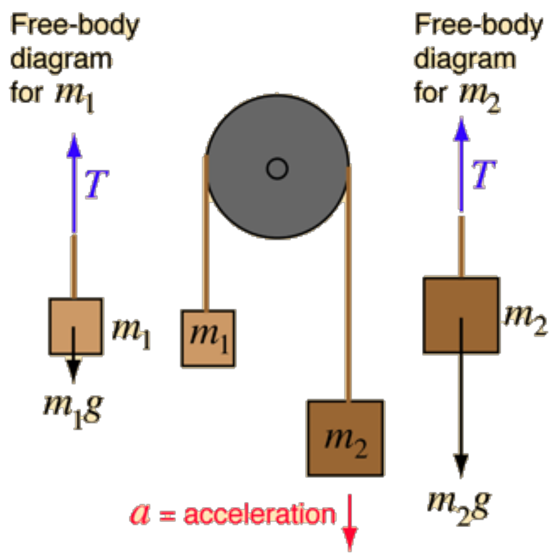
E, H: Atwood Machines Name ________________________

A: What are Atwood Machines?

An Atwood machine is a device used to measure and test Newton's Laws.

Diagram of an Atwood Machine:



In Part 1: We will understand the Atwood Machine as a *full system*:
[Which is by far the easier, more coherent way of understanding at Atwood Machine.]

In order to do this, there are only two formulas necessary:

Force of Gravity (Weight) $F_g = mg$ Force of Gravity = Mass * Free-Fall Acceleration in which, on earth, Free-Fall Acceleration = 9.8 m/s^2.
Newton's Second Law $\Sigma F = ma$ Net force of a system = (mass of the system) * (Acceleration of the System)

B: Simple Atwood Machine Problems
B.1. An Atwood machine has two masses on it.
[Assume the Atwood machine is frictionless and the string is massless.]
Mass 1= 0.5 kg [is on the right side]
Mass 2 = 0.3 kg [is on the left side]
Assume the Atwood machine is frictionless, and that the string is massless.
A) Draw a schematic of the Atwood machine

B) Draw a free-body diagram of the Atwood machine as a *full system*.
There are only two external forces acting on the Atwood Machine:
Unlike most Free-body diagrams that you create, in this free-body diagram forces will be directly *clockwise* or *counterclockwise*.

C) Find the net force acting on the Atwood Machine:

D) Find the *total mass* of the Atwood machine. [Remember that the string is massless.]
[We are thinking about *total mass* because the Atwood machine is a *system*.]

E) Use Newton's second law to find the acceleration of the Atwood machine.
Find both the magnitude and direction of acceleration.

B.2 An Atwood machine has two masses on it.
Mass 1= 1.5 kg [is on the right side]
Mass 2 = 2.2 kg [is on the left side]
Assume the Atwood machine is frictionless, and that the string is massless.

A) Draw a schematic of the Atwood machine.

B) Draw a free-body diagram of the Atwood machine.

C) Find the net force acting on the Atwood machine.

D) Find the total mass of the Atwood machine.

E) Use Newton's Second Law to find the acceleration of the Atwood machine. Give magnitude and direction.

 Name ________________________

B.3 An Atwood machine has two masses
Mass 1 [left side] = 0.9 kg
Mass 2 [right side] =0.8 kg

A) Draw a schematic of the Atwood machine.

B) Draw a free-body diagram of the Atwood machine.

C) Find the net force acting on the Atwood machine.

D) Find the total mass of the Atwood machine.

E) Use Newton's Second Law to find the acceleration of the Atwood machine. Give magnitude and direction.

B.4: Algebraic Atwood Machine:

Mass 1 [right side] = M
Mass 2 [left side] = m

Assume that $M > m$. For the free-fall acceleration, use g.

A) Draw a schematic of the Atwood machine.

B) Draw a free-body diagram of the Atwood machine.

C) Find the net force acting on the Atwood machine.

D) Find the total mass of the Atwood machine.

E) Use Newton's Second Law to find the acceleration of the Atwood machine. Give magnitude and direction.

Part C: Atwood Machines On a Frictionless Table:
These problems are similar to those in Part B, but have one slight addition.

C.1 Mass 1 = 0.7 kg is on the LEFT side
Mass 2 = 0.9 kg is on the RIGHT side
Mass 3 = 0.4 kg is on a *table* between two pulleys. The table is *frictionless*.

A) Draw a schematic of the Atwood machine.

B) Draw a free-body diagram of the Atwood machine.
[There are now going to be *FOUR* forces, *but* two of them will cancel each other out!]

C) Find the net force acting on the Atwood machine.

D) Find the total mass of the Atwood machine.

E) Use Newton's Second Law to find the acceleration of the Atwood machine. Give magnitude and direction.

C.2 An Atwood machine has *three* masses
Mass 1 = 2.9 kg is on the LEFT side
Mass 2 = 3.5 kg is on the RIGHT side
Mass 3 = 2.7 kg is a block on a *table* between two pulleys. The table is *frictionless*.

A) Draw a schematic of the Atwood machine.
B) Draw a free-body diagram of the Atwood machine.
C) Find the net force acting on the Atwood machine.
D) Find the total mass of the Atwood machine.
E) Use Newton's Second Law to find the acceleration of the Atwood machine. Give magnitude and direction.

C.3: An Atwood machine has three masses:
m_l on the left side
m_r on the right side
m_t on the table (which is frictionless)
Consider clockwise to be the *positive direction* and *counterclockwise* to b the negative direction.

A) Draw a schematic of the Atwood machine.
B) Draw a free-body diagram of the Atwood machine.
C) Find the net force acting on the Atwood machine.
D) Find the total mass of the Atwood machine.
E) Use Newton's Second Law to find the acceleration of the Atwood machine. Give magnitude and direction.

 Name ________________________

D: Atwood Machines with friction:
D.1 An Atwood machine ahs *three masses*
Mass 1 = 0.7 kg is on the LEFT side
Mass 2 = 0.4 kg is on the RIGHT side
Mass 3 = 0.3 kg is on a TABLE between the two pulleys. The coefficient of kinetic friction between the block and the table is 0.2.

A) Draw a schematic of the Atwood machine.

B) Draw a free-body diagram of the Atwood machine.
[There are now going to be *five* forces, *two* of them will cancel each other out, but *three* will help determine the acceleration of the machine.]

C) Find the net force acting on the Atwood machine.

D) Find the total mass of the Atwood machine.

E) Use Newton's Second Law to find the acceleration of the Atwood machine. Give magnitude and direction.

D.2 An Atwood machine has *three masses*
Mass 1 = 1.5 kg is on the LEFT side
Mass 2 = 1.0 kg is on the RIGHT side
Mass 3 = 0.4 kg is on a TABLE between the two pulleys. The coefficient of kinetic friction between the block and the table is 0.2.

D.3 An Atwood machine has *three masses*
m_l on the left side
m_r on the right side
m_t on the table.
The coefficient of kinetic friction between the table and the mass is μ.
Consider clockwise to be the *positive direction* and *counterclockwise* to b the negative direction.

Answers:

B.1 2.45 m/s^2 clockwise
B.2 1.85 m/s^2 counterclockwise
B.3 0.576 m/s^2 counterclockwise

B.4 Algebraic Atwood Machine:

$a = g\left(\frac{M-m}{M+m}\right)$ in the clockwise direction.

C.1 0.98 m/s^2 clockwise
C.2 0.646 m/s^2 clockwise

C.3

$$a = g\left(\frac{m_r - m_l}{m_r + m_l + m_t}\right)$$

The direction is clockwise if $m_r > m_l$
the direction is clockwise if $m_r < m_l$

D.1 1.68 m/s^2 counterclockwise
D.2 1.42 m/s^2 counterclockwise

D.3

$$a = g\left(\frac{m_r - m_l \pm \mu m_t}{m_r + m_l + m_t}\right)$$

In which the term $\pm$ is + if $m_l > m_r$ and – if $m_l < m_r$