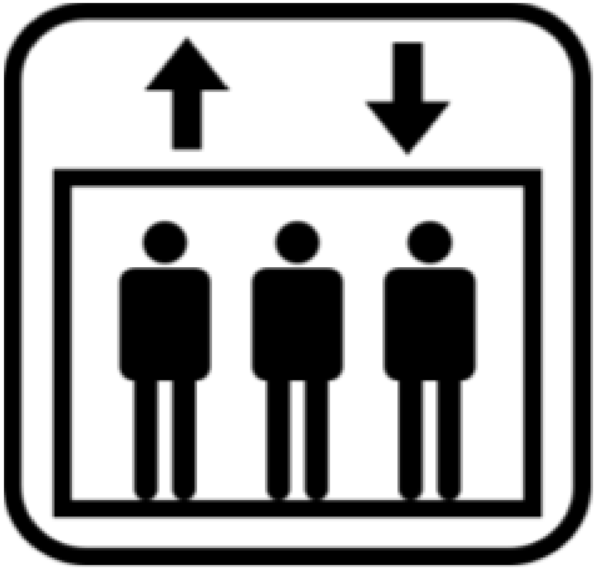
The Net Force in Elevator Problems and Pulleys



Question: What is an elevator?

An <u>elevator</u> is a device used for moving people from one story of a very large building to another story.

You might see one if you ever go to the city (cross your fingers, if you're lucky!!!)

Review:

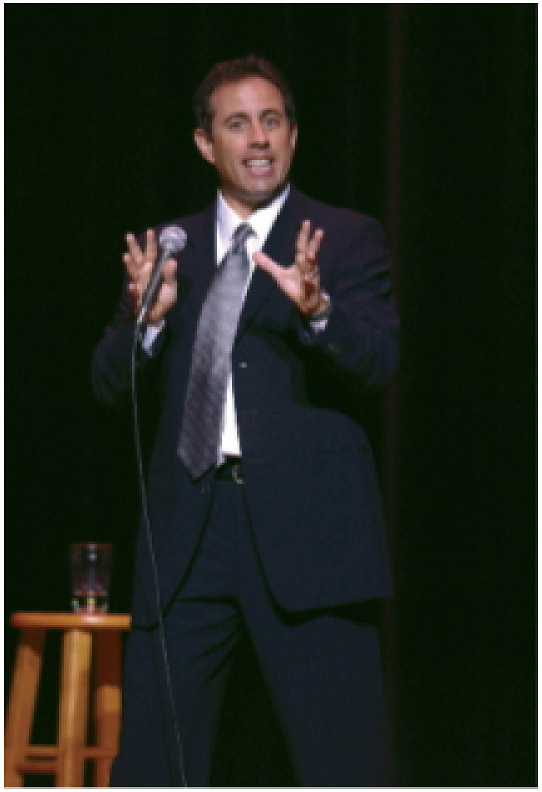
Why are amusement park rides exciting?

Review: Bathroom Scales

Would a bathroom scale work in space?

The thing about

Elevators



Have you ever noticed...

- when the elevator is at rest...

- when the elevator is starting upwards...

- when the elevator is starting downwards...

- in the middle of the ride...

Elevators work on the concept of the applied and total forces. It also brings to mind a new* force...tension.

Tension: a force applied by a rope, string, cable, etc. We assume the rope has no mass, no friction and does not stretch.

We will consider 4 scenarios:

1. **Elevator at rest.**
2. **Elevator starts up.**
3. **Elevator starts down.**
4. **Elevator at constant velocity.**

***This is really nothing new. Just a regular force with a new name.**

1. Elevator at rest.

What is the F_{tot}?

$$\vec{F}_{tot} = \vec{F}_T + \vec{F}_g$$

But since the elevator is at rest, the forces must be equal by Newton's _____ Law.

So, $\vec{F}_T = -\vec{F}_g$

$$\vec{F}_{tot} = -\vec{F}_g + \vec{F}_g$$

$$\vec{F}_{tot} = 0$$

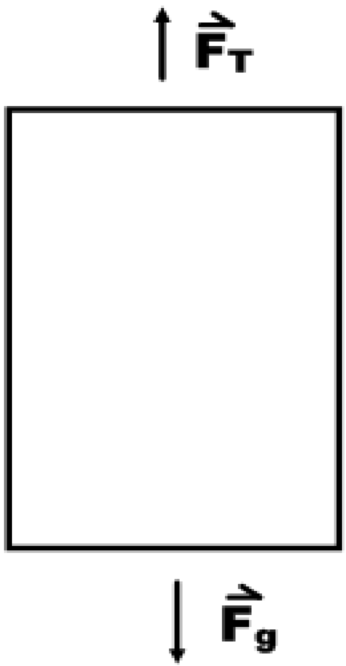
By Newton's ____ Law, if there is no force, there is no acceleration, so we don't feel anything!

4. Constant velocity.

This is also the case for when the elevator is moving with a cosntant velocity, as both cases represent

_______________ ________________.

2. Elevator starting up.



Since the elevator is going up, the tension must be greater than the force of gravity. The total force will be pointing upwards.

So, $\vec{F}_T > \vec{F}_g$

$$\boxed{\vec{F}_{tot} = \vec{F}_T + \vec{F}_g}$$

$\vec{F}_{tot}$ = +ive

By Newton's ____ Law, if there is an upwards force, there is an acceleration.

3. Elevator starting down.

Since the elevator is going down, the tension must be less than the force of gravity. The total force will be pointing downwards.

So, $\vec{F}_T < \vec{F}_g$

$$\boxed{\vec{F}_{tot} = \vec{F}_T + \vec{F}_g}$$

$\vec{F}_{tot}$ = -ive

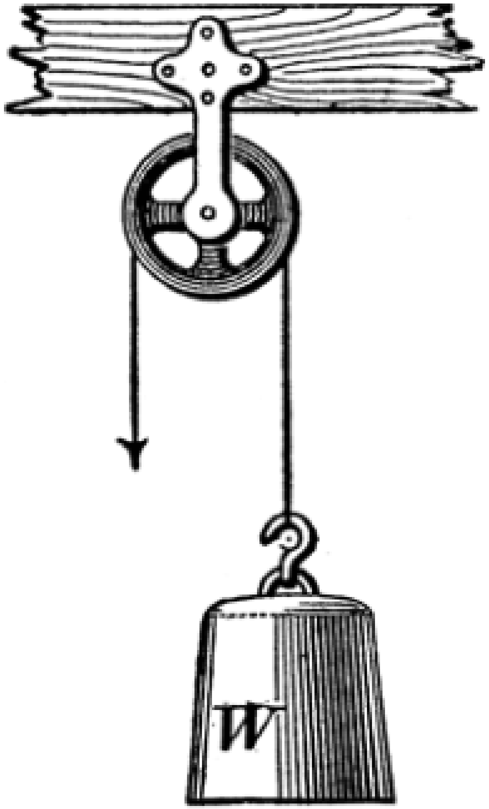
By Newton's ____ Law, if there is a downwards force, there is an acceleration.

ex) (pg 151) A person and an elevator have a combined mass of 6.00×10^2 kg. The cable exerts a tension of 6.50×10^3 N up on the elevator. What is the acceleration on the person?

Ans: $1.02\ m/s^2$

Pulleys

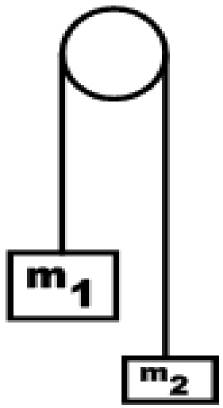
Many practical problems involve the use of one or more pulley. Here's a few pieces of info about pulleys:



- we assume the pulley system has no friction.

- the pulley only changes the direction of the force!

Atwood's Pulley



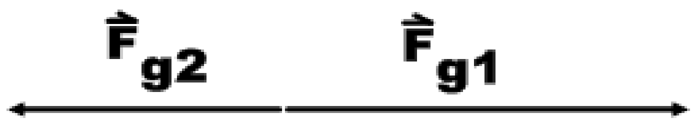
If $m_1 = 0.250$ kg

$m_2 = 0.100$ kg

What is the acceleration of the system?

*What are the forces acting on the pulley?

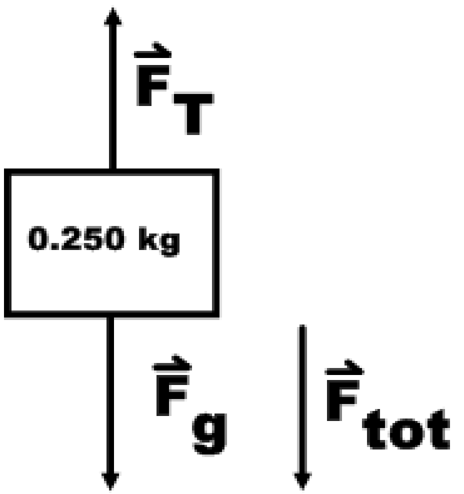
*Hint = the pulley only changes the direction of force. If you straighten out the diagram, it would look like this:



$$\vec{F}_{tot} = \vec{F}_{g1} + \vec{F}_{g2}$$

Key Tip: when finding the acceleration of the system, you must use the mass of the system!

ex) Find the tension in the rope in the previous problem.



$$\vec{F}_{tot} = \vec{F}_T + \vec{F}_g$$

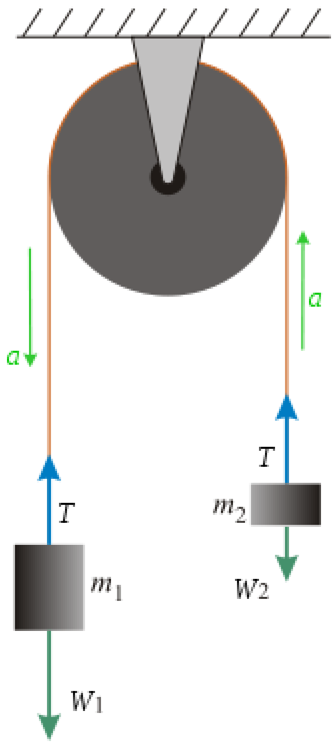
*Now consider only one mass (it doesn't matter which one). Draw a free-body diagram.

*For the total force, use the acceleration of the system.

*For the mass, use the mass of the single pulley.

*Mind your integers!

Calculating Tension



- Forces affecting m_1: $m_1 a = T - m_1 g$
- Forces affecting m_2: $m_2 a = m_2 g - T$
- and adding the two previous equations we obtain

$$m_1 a + m_1 g = m_2 g - m_2 a$$

- and our concluding formula for acceleration

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

Tension Continued

- Solving for a in the previous formulas, then equating the two formulas (thus getting rid of a), and solving for T we get:

$$T = \frac{2gm_1m_2}{m_1 + m_2}$$

Two Pulley Systems

- the same as before, now with double the pulleys for double the fun!!!

A box of mass 15 kg is on a horizontal frictionless table. Attached via pulleys are two masses, one 7.0 kg and one 9.0 kg. What is the acceleration of the system?