Walk-in Lab 4  
Acceleration in an elevator  
Physics 121

CID(s): 

Description

Do you know that weird feeling you get in your stomach when you ride in an elevator? Today you get to measure it! When an elevator starts to move upwards, the floor pushes up on your feet and you accelerate. When an elevator starts to move down, the floor falls away from you and pushes on you less. So you accelerate down.

In today’s lab, you will measure this effect using two different kinds of scales. The first is an ordinary bathroom spring scale. This scale measures the contact force between your feet and the elevator floor. When the elevator accelerates, the amount that the floor pushes up on you changes and this scale will measure that change. The second scale is a medical beam scale. Using a series of joints and levers, it compares your weight to a reference weight. As the elevator accelerates, your acceleration changes – but so does the reference weight. So these two scales really measure two totally different things. Cool!

Remember, you can work in groups of up to three people. The scales are in the south ESC elevators, the ones nearest S415 ESC. Have fun figuring out your “real” weight.

Objective: There are two very interesting parts to this lab:

1. Measuring the influence of an accelerating reference frame on your apparent weight.
2. Understanding the forces acting on objects when they accelerate.

Equipment: One bathroom spring scale and one medical beam scale in the south elevators near S415 ESC.

Part A – Your weight on a bathroom spring scale

When you get on the elevator, step onto the spring scale (the little one). Record your weight. Then press the button to go to another floor. Write down what the scale reads when the elevator is accelerating downwards, when it is moving at constant speed between floors, and when it is accelerating upwards. The elevator acceleration is not exactly the best controlled quantity in the universe, so when repeating this, your answers will change a bit. But write something that looks like your readings here:

1. When the elevator is at rest: ____________
2. When the elevator is accelerating downwards: ____________
3. When the elevator is moving at constant speed between floors: ____________
4. When the elevator is accelerating upwards: ____________

Analysis: On the back of this page, draw a force diagram showing your acceleration and the forces acting on you as you stand on a spring scale in the elevator. Remember, only consider the forces that are acting on you (there should be two). If you are at rest or moving in a straight line at constant speed, the forces will exactly balance. But if you are accelerating, the forces will not balance and you will accelerate.

You can find your mass by dividing your gravitational force by the gravitational acceleration: \( m_{\text{you}} = \frac{F_{\text{grav}}}{g} \). With this information, you can find your acceleration when the elevator starts and stops: \( a = \frac{F_{\text{scale}}}{m_{\text{you}}} - g \). What are the maximum and minimum accelerations of the elevator?

\( a_{\text{max}} = \) ____________ \( a_{\text{min}} = \) ____________
Part B – Your weight on a medical beam scale

Now you will need to repeat your four “weight” measurements using the big scale. When the elevator is not moving, step onto the scale and slide the little weights (called “poise”) until the beam is exactly horizontal and balanced. If the balance beam is tipped down, the weights on the slide are too far to the right. This happens if the weights are set to 185 pounds and your weight is 150. On the other hand, if the balance beam is tipped up the weights on the slide are too far to the left. This happens if the weights are set to 120 pounds and your weight is 150. So when the elevator is not moving, set the weights to read your actual weight with the balance beam exactly horizontal. While the elevator is accelerating, watch the balance beam to see if it tips up (you “weigh” more) or down (you “weigh” less) or if it stays balanced. Write what you see here:

1. When the elevator is at rest:  
2. When the elevator is accelerating downwards:  
3. When the elevator is moving at constant speed between floors:  
4. When the elevator is accelerating upwards:  

At the beginning of this lab, I described a little about how this beam scale works. With that explanation in mind, tell me why this scale responds differently to the elevator’s acceleration. Remember: this scale measures the difference between two masses. If the reference frame (like the elevator in which the scale is sitting) starts to accelerate, what happens to the apparent weights of the two masses. Will the change in apparent weight of the two masses be the same or will it be different? Can you tell why? Write your thoughts here:

It might (or might not) be helpful to think about the medical beam scale like those ancient scales of justice, kind of like in this figure. If the support in the middle starts to accelerate upwards, what will happen to the relative weights?