SectionK: Elevators 2

This section continues on the same concepts as in Elevators 1. The First few pages are the same. However, now we are going to consider people that are both speeding up and slowing down. You are going to find that elevators can be extremely counterintuitive when the net force acting on your is actually in the opposite direction as your motion!

Goal:

Imagine you are in an elevator. You feel various forces upward and downward on your body as the elevator moves up and down, and yet these forces do not always comply with the direction an elevator is moving.

The object of this packet is to create a mathematical model that explains the motion and forces on your body within an elevator.

Directions:

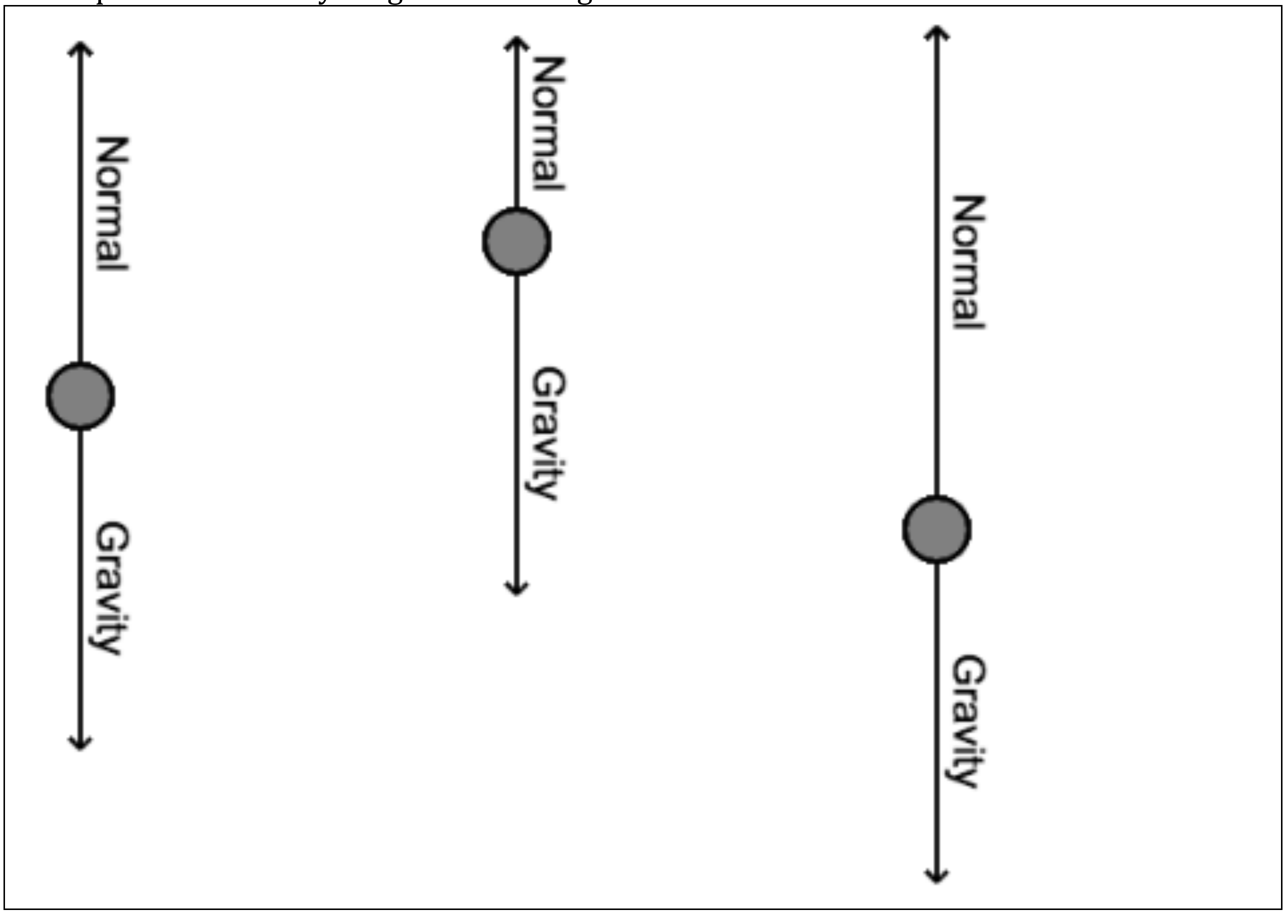
Skim the first two pages, labeled the **Elevator Rules**.

The first two pages set out the Laws of Physics that you need to know in order to answer the questions on other pages.

Then, approach the questions on other pages. Whenever you try one of these questions look *back* to the statements on the first two pages.

Elevator Problems Name ____________________

Elevator Rules:
Inside the elevator, there are always *two forces* acting on the object: gravity and the normal force. These forces are always there, and always act in the same directions:
Examples of Free-Body Diagrams that might be correct:



Gravity:

The *direction* of gravity is always DOWN.
The *magnitude* of gravity is always (mass)*(9.81 m/s^2)
This is written:

$$F_g = mg$$

Symbol	Quantity	SI Unit
F_g	Force of gravity	Newtons (N)
m	Mass	Kilograms (kg)
g	Free-fall acceleration [equal to 9.81 m/s^2 on earth]	m/s^2

Note that, because we are on earth, gravity is also referred to as *weight*.

Normal Force:

The *direction* of normal force is always perpendicular to the floor.
Inside of an elevator, this is always UP.

The *magnitude* of normal force is always equal to *whatever it must be in order to match the motion provided*.
Normal force is called a **constraint force.**

Newton's Second Law:

$$\Sigma F = ma$$

If an object is not moving, the net force is always equal to zero.
If an object is moving at a *constant velocity*, the net force is always equal to zero.
If an object is *speeding up*: then the net force is not equal to zero and is in the *same direction* as velocity.
If an object is *slowing down*: then the net force is not equal to zero and is in the *opposite direction* as velocity.

Forces you Feel:

Human beings do not actually, ever in their lives, *feel* the force of gravity.
The force that human beings describe as 'gravity' or 'weight' is the normal force

If the magnitude of the normal force is equal to the weight of a person, then they feel normal.
If the magnitude of the normal force is less than the weight of a person, then they feel 'light' or 'weightless'
If the magnitude of the normal force is greater than the weight of a person, then they feel 'heavy' or 'pressed into.'

Elevator Problems Name ____________________

Problem K1:
Evan the Elevator Man is standing in an elevator. The elevator is *moving downward* and also is *speeding up at a rate of* 1.1 m/s^2.
Evan has a mass of 67 kg.

What is the *direction of net force* acting on Evan?

What is the *magnitude of net force* acting on Evan?

Picture of Evan	**Free-Body Diagram**	**Net Force Vector**	**Velocity Vector**

Name of Force	**Magnitude**	**Direction**	**How did you determine the magnitude?**
Gravity			
Normal Force			

What does Evan *feel* while in the elevator?
A. nothing
B. weightlessness, lightness
B. heaviness, a feeling of being pressed inward

Explain how you know, by referring to the information on page 2.

Problem K.2:
Elizabeth the Elevator Woman is standing in an elevator. The elevator is *moving upward* and is *speeding up* at a rate of 1.2 m/s^2.
Elizabeth has a mass of 63 kg.

What is the *direction of net force* acting on Elizabeth?

What is the *magnitude of net force* acting on Elizabeth?

Picture of Elizabeth	**Free-Body Diagram**	**Net Force Vector**	**Velocity Vector**

Name of Force	**Magnitude**	**Direction**	**How did you determine the magnitude?**
Gravity			
Normal Force			

What does Elizabeth *feel* while in the elevator?
A. nothing
B. weightlessness, lightness
B. heaviness, a feeling of being pressed inward

Explain how you know.

Elevator Problems Name ____________________

Problem K3:
Elevatin' Earl is standing in an elevator. The elevator is *moving upward* and *slowing down* at a rate of 0.6 m/s^2.
Earl has a mass of 72 kg.

What is the *direction of net force* acting on Earl? [look carefully on page 2 and think about how to apply Newton's Second Law!] Explain how you know.

What is the *magnitude of net force* acting on Earl?

Picture of Earl	**Free-Body Diagram**	**Net Force Vector**	**Velocity Vector**

Name of Force	**Magnitude**	**Direction**	**How did you determine the magnitude?**
Gravity			
Normal Force			

What does Earl *feel* while in the elevator?
A. nothing
B. weightlessness, lightness
B. heaviness, a feeling of being pressed inward

Explain how you know.

Elevator Problems Name ____________________

Problem K4:
Eve, President of the Elevation Nation, is in an elevator. It is moving *downward* and *slowing down* at a rate of 0.9 m/s^2
Eve has a mass of 68 kg.

What is the *direction of net force* acting on Eve? [look carefully on page 2 and think about Newton's Second Law!] Explain how you know.

What is the *magnitude of net force* acting on Eve?

Picture of Earl	**Free-Body Diagram**	**Net Force Vector**	**Velocity Vector**

Name of Force	**Magnitude**	**Direction**	**How did you determine the magnitude?**
Gravity			
Normal Force			

What does Eve *feel* while in the elevator?
A. nothing
B. weightlessness, lightness
B. heaviness, a feeling of being pressed inward

Explain how you know.

K.5: A Conceptual Question

When I was a kid, my sister and I rode up in a high-speed elevator, and when we reached the top floor, it felt like we were *falling down*. My sister said, “the elevator must go too high, and then needs to go back down to reach the right floor!.” But this is *not true*! The elevator is very precisely stopping at the correct floor and doesn’t go to far at all.

Using the physics learned in this packet, explain why it *feels like* you are falling down when you reach the top of an elevator.

Use *each of* the concepts of velocity, acceleration, net force, weight, and normal force to make your argument.

Elevator Problems Name ____________________

Answers:

Problem K.1:
Net Force = 73.7 N DOWNWARD

Name of Force	**Magnitude**	**Direction**	**How did you determine the magnitude?**
Gravity	657 N	DOWN	
Normal Force	584 N	UP	You must have this normal force for the correct net force.

Evan *feels* a sensation of falling because the normal force is less than his weight.

Problem I.2:
Net Force = 75.6 N UPWARD

Name of Force	**Magnitude**	**Direction**	**How did you determine the magnitude?**
Gravity	618 N	DOWN	
Normal Force	694 N	UP	You must have this normal force for the correct net force.

Elizabeth feels *heavy* and feels as through the floor is pressing into her, because the normal force acting on her is greater than her weight.

Elevator Problems Name ____________________

Problem I.3:
Net Force = 43.2 N DOWNWARD (the net force must be downward because he is *moving upward* but is *slowing down*. Net force and velocity are in opposite directions if you are slowing down.

Name of Force	**Magnitude**	**Direction**	**How did you determine the magnitude?**
Gravity	706 N	DOWN	
Normal Force	663 N	UP	

Earl *feels* like he is falling because the normal force acting on her is less than her weight.

Problem I.4:
Net Force = 61.2 N UPWARD (the direction of net force is opposite the velocity because the person is *slowing down*.)

Name of Force	**Magnitude**	**Direction**	**How did you determine the magnitude?**
Gravity	667 N	DOWN	
Normal Force	728 N	UP	

Eve feels heavy because the normal force acting on her is greater than her weight.