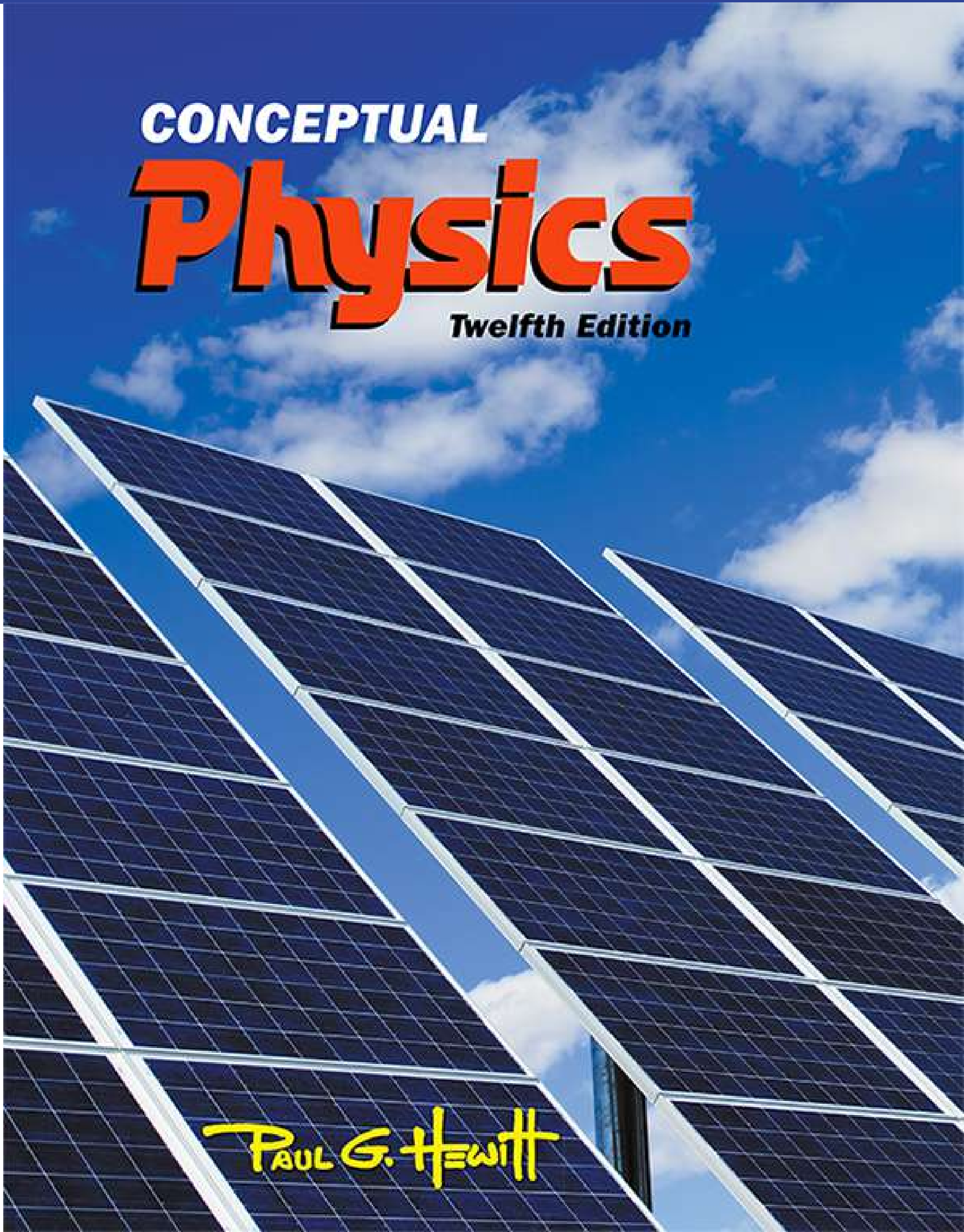
Lecture Outline

Chapter 9: Gravity

Section 4: Weight and Weightlessness



This lecture will help you understand:

- When weight = the force of gravity
- When it doesn't

- How you can *gain* weight on an elevator
- How you can *lose* weight on an elevator

- How to become *weightless*

Weight and Weightlessness

- Weight:
  - force an object exerts against a supporting surface
  - ALWAYS equals the scale reading
  - ***not*** always equal to the force of gravity!

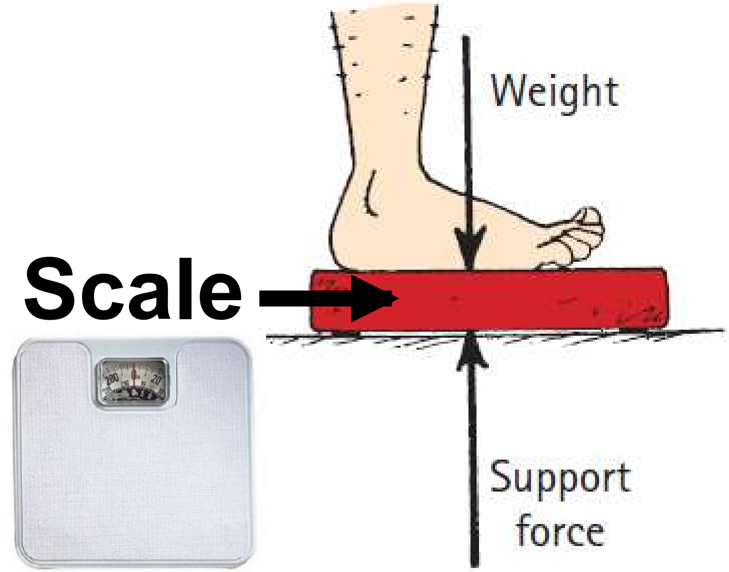


FIGURE 9.8
When you step on a weighing scale, two forces act on it: a downward force of gravity, *mg*, and an upward support force. These two forces are equal and opposite when no acceleration occurs, and they squeeze a spring-like device inside the scale that is calibrated to show your weight.

Weight and Weightlessness

- Weight:
  - force an object exerts against a supporting surface
  - not always the same as the force of gravity!
  - what a scale reads

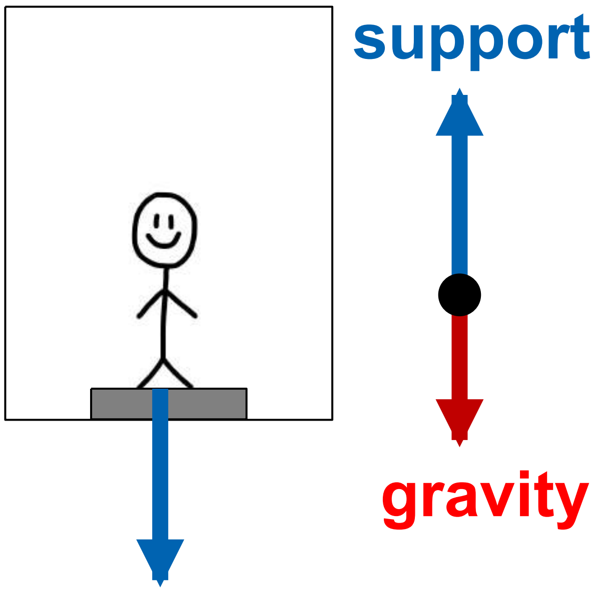
Example: In an elevator, you can have different weights, depending on its motion:

- Case 1: Accelerating upwards
- Case 2: Constant velocity upwards or downwards
- Case 3: Accelerating downwards

Case 1: Accelerating upwards

This happens if you…

1. …are moving **upwards** with *increasing* speed; or
2. …are moving **downwards** with *decreasing* speed.



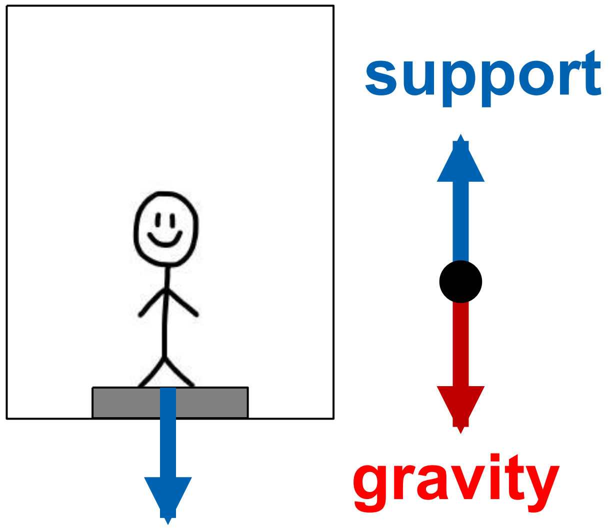
- The net force is upward.
- Scale must exert a normal (support) force on you that is greater than the force of gravity
- *N's 3rd Law:* You exert a greater force on the scale
- → more compression in scale springs
- → weight is **greater** (you "gain weight")!

Case 2: No acceleration

This happens if you…

1. …at rest
2. …are moving up or down

   at **constant** speed

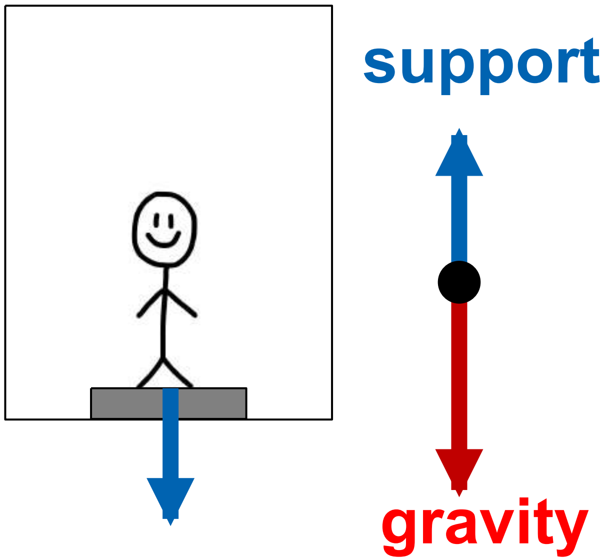


- The net force is zero.
- Scale must exert a normal (support) force on you that is equal to the force of gravity
- *N's 3rd Law:* You exert a force down equal to gravity
- →same compression in scale springs
- → weight is **the same** as the force of gravity

Case 3: Accelerating downwards

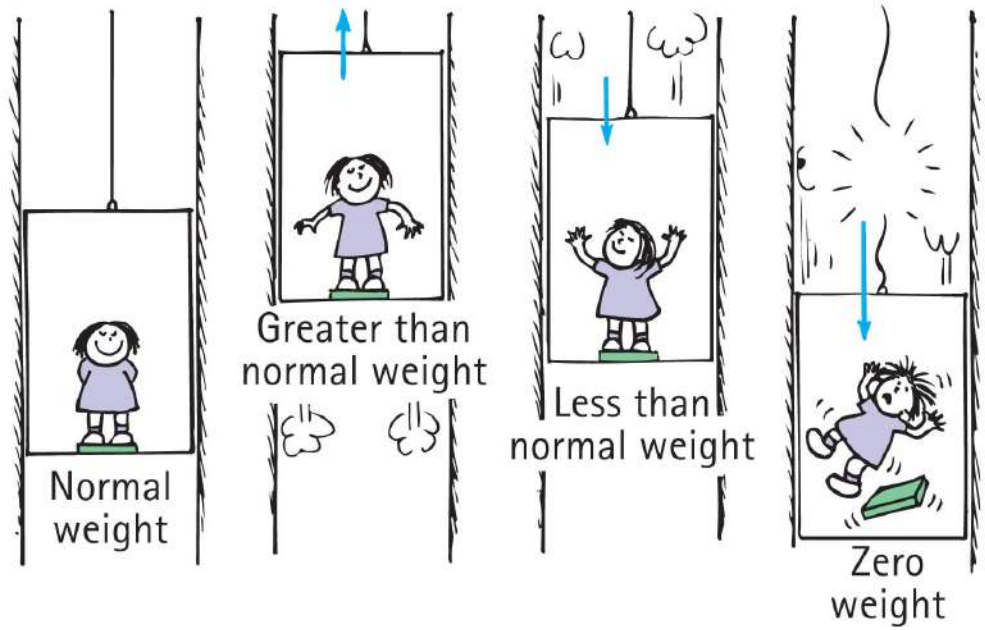
This happens if you…

1. …are moving **downwards** but with *increasing* speed; or
2. …are moving **upwards** with *decreasing* speed



- The net force is downward.
- Scale must exert a normal (support) force on you that is *less* than the force of gravity
- *N's 3rd Law:* You exert a smaller force on the scale
- less compression in scale springs
- weight is **less** (you "lose weight")!

Weightlessness



If the elevator cable breaks, you will be in free fall. Only gravity pulls you down.

There is no support force from the scale. What will the scale read? 0

What is your weight? 0

In which case is the force of gravity the most? all the same

In which case is the acceleration = 9.8 m/s^2? last case

Weight and Weightlessness, Continued

- Weightlessness:
  - no support force, as in free fall
  - Example: Astronauts in orbit are without support forces and are in a continual state of weightlessness.
  - anytime you jump in the air!

CHECK POINT

In what sense is drifting in space far away from all celestial bodies like stepping down off a stepladder?

Weight and Weightlessness
CHECK YOUR NEIGHBOR

When an elevator accelerates upward, your weight reading on a scale is

A. greater.
B. less.
C. zero.
D. the normal weight.

Weight and Weightlessness
CHECK YOUR ANSWER

When an elevator accelerates upward, your weight reading on a scale is

A. **greater.**

Explanation:

The support force pressing on you is greater, so you weigh more.

Weight and Weightlessness
CHECK YOUR NEIGHBOR, Continued

When an elevator accelerates downward, your weight reading is

A. greater.
B. less.
C. zero.
D. the normal weight.

Weight and Weightlessness CHECK YOUR ANSWER, Continued

When an elevator accelerates downward, your weight reading is

B. **less.**

Explanation:

The support force pressing on you is less, so you weigh less. Question: Would you weigh less in an elevator that moves downward at constant velocity?

Weight and Weightlessness CHECK YOUR NEIGHBOR, Continued-1

When the elevator cable breaks, the elevator falls freely, so your weight reading is

A. greater.
B. less.
C. zero.
D. the normal weight.

Weight and Weightlessness
CHECK YOUR ANSWER, Continued-1

When the elevator cable breaks, the elevator falls freely, so your weight reading is

C. **zero.**

Explanation:

There is still a downward gravitational force acting on you, but gravity is not felt as weight because there is no support force, so your weight is zero.

Weight and Weightlessness
CHECK YOUR NEIGHBOR, Continued-2

If you weigh yourself in an elevator, you'll weigh more when the elevator

A. moves upward.
B. moves downward.
C. accelerates upward.
D. All of the above.

Weight and Weightlessness
CHECK YOUR ANSWER, Continued-2

If you weigh yourself in an elevator, you'll weigh more when the elevator

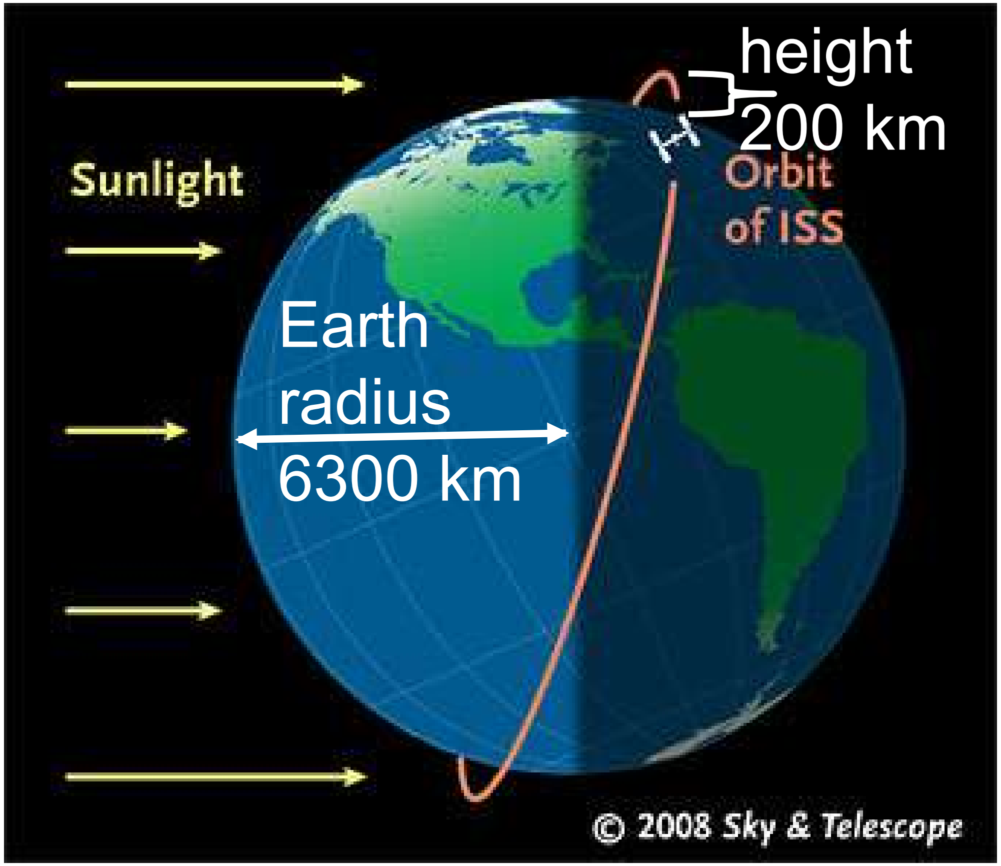
A. **accelerates upward.**

Explanation:

The support provided by the floor of an elevator is the same whether the elevator is at rest or moving at constant velocity. Only accelerated motion affects weight.

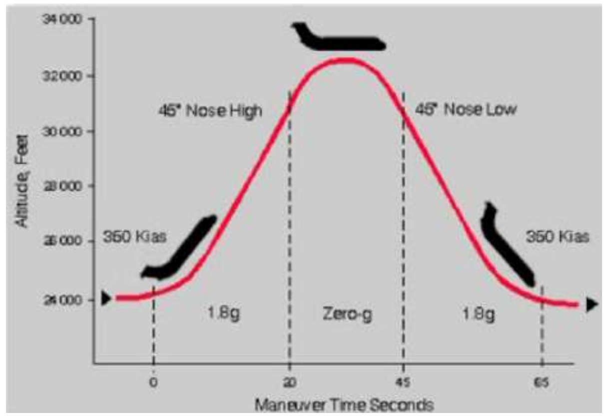
Free fall: Weightless because everything is falling—no support force!

In the international space station (ISS), gravity is about 90% of Earth's: plenty of gravity…no weight!



Training for weightlessness (free fall):

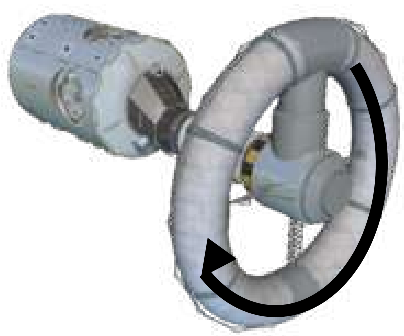
The “vomit comet” = an airplane in free fall used to train astronauts.



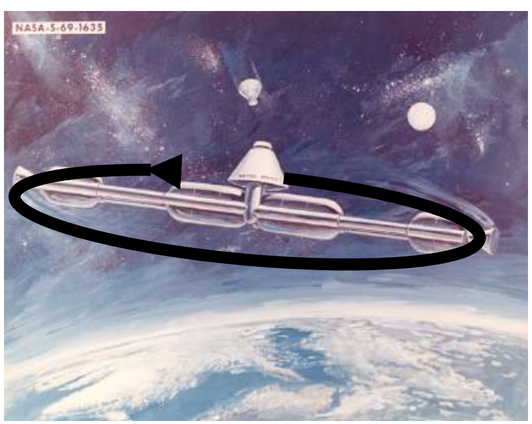
Creating weight in space:

Long periods of weightlessness causes bone loss, heart problems, and other health issues.

To create weight (without gravity), rotate the station!



NASA plan:



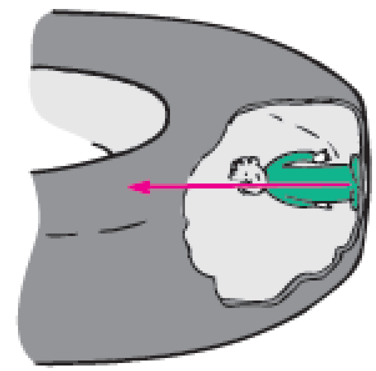


FIGURE 8.48
The interaction between the man and the floor, as seen from a stationary frame of reference outside the rotating system. The floor presses against the man (action), and the man presses back on the floor (reaction). The only force exerted on the man is by the floor. It is directed toward the center and is a centripetal force.

Take out a sheet of paper and put your name at the top. Answer these questions:

11. Would the springs inside a bathroom scale be more compressed or less compressed if you weighed yourself in an elevator that was accelerating upward? Downward?

12. Would the springs inside a bathroom scale be more compressed or less compressed if you weighed yourself in an elevator that was moving upward at *constant velocity*? Downward at *constant velocity*?

13. When is your weight measured as mg?

14. Give an example of when your weight is greater than mg. Give an example of when your weight is zero.

15. Why are International Space Station occupants weightless when they are firmly in the grip of Earth's gravity?

Take photo of your answers.
Submit to Teams. Now.
Due by end of hour.