Physics 111
Lecture 09
Thursday, September 23, 2004

- Ch 5: Newton’s 1st and 2nd Laws
  Example Problems

- Ch 6: Intro to Friction
  static
  kinetic

Announcements

The Physics 111 Help Session

Help this week:
Wednesday, 8 - 9 pm in NSC 118/119
Sunday, 6:30 - 8 pm in CCLIR 468

Labs Meet This Week

Don’t forget to read over the lab write-up and be ready for the quiz.

Ch 5: Newton’s Laws

Let’s go back to a ball tossed vertically upwards. Once I let go, I’m not touching it anymore.

Why is it moving upwards after I let go?

Newton’s First Law - Inertia. Although gravity is the only force and it acts downward, the ball had initial velocity upward.

Ch 5: Newton’s Laws

What did we learn?

- Force is proportional to acceleration.

- Given the same force, the acceleration of an object is inversely proportional to its mass.

- Acceleration and the response to a force do not depend upon initial velocities!

Note:

Force is a VECTOR quantity—that means you MUST specify both magnitude and direction.

\[ \vec{a} = \frac{F_{\text{net}}}{m} \]

The direction of the force vector is the same as the direction of the acceleration vector!
What happens to the falling ball? Does the time it takes the ball to reach the ground:
1) increase
2) decrease
3) remains the same as for the case without the wind.

Consult with Neighbors!

King Henry’s “weight” is equal to the force of gravity acting downward (toward the Earth).

Here the acceleration due to gravity ($g$) is the familiar $9.81 \text{ m/s}^2$.

However, we can also talk about the “weight” of an object on the moon or some other planet as opposed to its weight on Earth...

An astronaut on the Moon weighs roughly 1/6 of what he does on Earth.

Remember that “Weight” is just one type of force (e.g., friction, tension, normal) that can appear in $F_{\text{net}}$ in Newton’s 2nd Law.

By weight, we mean the gravitational force of one object with “gravitational mass” on another.

We’ve already looked at this quantity. Recall, it is an inherent property of the object and describes the object’s resistance to acceleration from the imposition of an outside force. We therefore called it

Inertial Mass

Is there any reason we should apriori expect the proportionality constant to be the SAME for the relationship between the force of gravity and acceleration of gravity?

Is the slope of this line necessarily the same mass as we found before?

Not necessarily...
To be most general, let's call the slope of THESE lines the "gravitational mass" and assume that it is possibly a new, yet inherent property of the planet.

Here, the different lines could represent different planets, perhaps Saturn, Earth, and Mars.

Experiment 1: We use our force meter and our frictionless surface to measure the force on and acceleration of two spherical balls. Let's say that this experiment tells us that the inertial masses of the two balls are in a ratio of 2:1.

Experiment 2: We take the same two spherical balls and measure the gravitational force they exert on a third ball. The force observed now depends upon the gravitational masses of the balls. We find experimentally that the two forces are in exactly the same ratio of 2:1.

We therefore conclude from our experiment that

\[ \text{Gravitational Mass} = \text{Inertial Mass} \]

A TRULY REMARKABLE RESULT!!

Final thoughts...

Remember...

- The mass of an object is an inherent property of that object. It does not change from place to place in the universe.
- Weight is the gravitation force on an object and will change from place to place...

Try the "elevator experiment"

Note the following:

- How does your weight change while you're...
  - Ascending?
  - Descending?
  - Decelerating?
  - Accelerating?
A bank officer pushes a safe of mass 750 kg up a frictionless incline with a slope of 20° to the horizontal. The bank officer applies a horizontal force of 3500 N. Determine the acceleration of the safe.

Problem Worksheet: safe

Draw a motion diagram, a full pictorial representation, and a free-body diagram, then use Newton’s 2nd Law to answer this question.

Chapter 6
Applications of Newton’s Laws

Now that we have seen and applied Newton’s Laws (at least a few times), let’s introduce a couple of new forces.

I will NOT cover everything in this chapter...

What is friction?

A macroscopic (meaning, observable to the eye) force that operates at the interface between two surfaces in a direction to oppose the slipping of those surfaces across one another.

As I push on the red block with some force, friction with the surface of the blue block acts to prevent the red block from sliding.

What is friction?

First, make a pictorial representation and describe the forces present.

\( F_n = \) normal force of bottom block on top block

\( F_{\text{ext}} = \) the external force pushing the block

\( f_s = \) frictional force of bottom block on top block

\( F_g = \) weight or the gravitational force of Earth on block

Now let’s draw the FBD for the red block...
This force is described as the force of static friction, as it relates to the force observed on a pair of objects that do not slip relative to one another.

We find that experimentally, the magnitude of the maximum force of static friction is proportional to the normal force exerted by the blue block on the red block.

If I push hard enough, the force of static friction will be broken and slipping will occur at the interface. The red block will begin to accelerate relative to the blue block.

When the red block slips, we note that it still feels a frictional force. The magnitude of that force, however, has changed.

If I push hard enough, the force of static friction will be broken and slipping will occur at the interface. The red block will begin to accelerate relative to the blue block.

We find experimentally that the maximum value of the frictional force is still proportional to the normal force exerted by the blue block on the red block.

This force is described as the force of kinetic friction, as it relates to the force observed on two objects that slip relative to one another.

The constant of proportionality is known as the coefficient of kinetic friction ($\mu_k$) and is a property of the materials at the interface.

The constant of proportionality is known as the coefficient of static friction ($\mu_s$) and is a property of the materials at the interface.
The frictional forces are always directed so as to oppose the slippage between the two surfaces.

Static Case: Object at rest

\[ |\vec{f}_s| \geq \mu_s |\vec{n}| \]

Kinetic Case: Object in Motion

\[ |\vec{f}_k| = \mu_k |\vec{n}| \]

Does friction always result in an object slowing down?

Let’s look at a couple of examples to find out...

What's going to happen to the green object as I push the blue book across the table?

Worksheet Problem #5a  Consult with neighbors.

What happened to the green object this time as I pushed the blue book across the table?

Worksheet Problem #5b  Consult with neighbors.