Instructor: Gordon D. Cates
Office: Physics 106a, Phone: (434) 924-4792
email: cates@virginia.edu

Course web site available through COD and Toolkit
or at http://people.virginia.edu/~gdc4k/phys106/spring07

January 24, 2007
Let's consider a ball that is just sitting on a table.

Is the baseball accelerating?

If not, what does that say about the "net force" on the ball?

What are the forces on the ball?
What are all the forces on the baseball when it is sitting on the table?
What are all the forces on the baseball when it is sitting on the table?

One force is that due to gravity, its weight: \( w = m \cdot g \)
What are all the forces on the baseball when it is sitting on the table?

But there is also a force on the baseball from the table: the “support” or “normal” force.

One force is that due to gravity, its weight: \( w = m \cdot g \)
What is the “support force” or “normal force”? 

- It is a new type of force that we have not yet discussed.
- Prevents something from penetrating a surface.
- Points directly away from that surface.
- Actually has its origins at the atomic level!
Physics concept

- **Net force**
  - The sum of all forces on an object
Another question: why is it that the normal force exactly balances the force due to gravity?

weight: $w = m \cdot g$
Another question: why is it that the normal force exactly balances the force due to gravity?

There is actually something quite basic going on here.

force due to gravity
weight: \( w = m \cdot g \)
Newton’s third Law

For every force that one object exerts on a second object, there is an equal but oppositely directed force that the second object exerts on the first object.
Newton's third Law

For every force that one object exerts on a second object, there is an equal but oppositely directed force that the second object exerts on the first object.

Force on table due to ball’s weight: $m_{\text{Ball}} \cdot g$
Newton’s third Law

For every force that one object exerts on a second object, there is an equal but oppositely directed force that the second object exerts on the first object.

Force on ball due to the “support force” from the table (also with magnitude $m_{\text{Ball}} \cdot g$)

Force on table due to ball’s weight: $m_{\text{Ball}} \cdot g$
Newton’s third Law

For every force that one object exerts on a second object, there is an equal but oppositely directed force that the second object exerts on the first object.

Note that on this slide I am showing the force of the ball on the table, and the force of the table on the ball, NOT ALL THE FORCES ARE ACTING ON THE BALL.
Experiment

If you push on a friend who is moving away from you, how will the force you exert on your friend compare to the force your friend exerts on you?
Experiment

If you push on a friend who is moving away from you, how will the force you exert on your friend compare to the force your friend exerts on you?

- You push harder.
- Your friend pushes harder.
- The forces are equal in magnitude.
Forces present in the problem of a ball sitting on a table

1. On earth due to gravity from the ball.
2. On ball due to gravity from the earth.
3. On ball due to support from table.
4. On table due to support from ball.
Forces present in the problem of a ball sitting on a table

1. On earth due to gravity from the ball.
2. On ball due to gravity from the earth.
3. On ball due to support from table.
4. On table due to support from ball.

“3rd law pair”
Forces present in the problem of a ball sitting on a table

1. On earth due to gravity from the ball.
2. On ball due to gravity from the earth.
3. On ball due to support from table.
4. On table due to support from ball.

“3rd law pair”
“3rd law pair”
Forces present in the problem of a ball sitting on a table

1. On earth due to gravity from the ball.
2. On ball due to gravity from the earth.
3. On ball due to support from table.
4. On table due to support from ball.

Since the ball does not accelerate, forces 2 and 3 must cancel perfectly!
Two crucial notes

• While the forces two objects exert on one another must be equal and opposite, the net force on each object can be anything.

• Each force within an equal-but-opposite pair is exerted on a different object, so they don't cancel directly.
Question:

Can a ball ever push downward on a table with a force greater than its weight?
Now we move to a discussion of a new subject: ramps. We begin with another question:

Will a ball that is rolled down a ramp fall at the same rate as a ball that is simply dropped?
Observations about ramps

- Lifting an object straight up is often difficult.
- Pushing the object up a ramp is usually easier.
- The case depends on the ramp’s steepness.
- Shallow ramps require only gentle pushes.
Physical quantities:
Physical quantities:

- Energy
Physical quantities:

• **Energy**
  
  - A conserved quantity.
Physical quantities:

- Energy
  - A conserved quantity.
  - One form is the capacity to do work.
Physical quantities:

• Energy
  – A conserved quantity.
  – One form is the capacity to do work.

• Work
Physical quantities:

- **Energy**
  - A conserved quantity.
  - One form is the capacity to do work.

- **Work**
  - The mechanical means of transferring energy.
Physical quantities:

- **Energy**
  - A conserved quantity.
  - One form is the capacity to do work.

- **Work**
  - The mechanical means of transferring energy
  - work = force \cdot distance
Physical quantities:

• Energy
  – A conserved quantity.
  – One form is the capacity to do work.

• Work
  – The mechanical means of transferring energy
  – work = force \cdot distance

(Where the force and distance are in the same direction.)
Work lifting ball

• Going straight up
  – Force is large
  – Distance is small
Work lifting ball

- Going straight up
  - Force is large
  - Distance is small

\[
\text{Work} = \text{force} \cdot \text{distance}
\]
Most of the weight is counteracted by the support force. However, the support force can only be normal to the surface of the ramp. Thus, there is still a small net force that points down along the ramp.
Work lifting ball

• **Going up ramp**
  - Force is small
  - Distance is large
Work lifting ball

- Going up ramp
  - Force is small
  - Distance is large

\[
\text{Work} = \text{force} \cdot \text{distance}
\]
Work lifting ball

• Going straight up:

\[ \text{Work} = \text{force} \cdot \text{distance} \]

• Going up ramp:

\[ \text{Work} = \text{force} \cdot \text{distance} \]

• The work is the same either way!