Physics 1010: The Physics of Everyday Life

TODAY
• Rolling Friction
• Hook’s Law, Springs
Today

• Rolling Friction
• Units
• Springs
  ✓ Hooke’s law, $F = -kx$. Experiments to check when and if it holds
  ✓ Scales
  ✓ Springs in your life
What do Most People Around You Think About The Homework?

A They look like they’re easy to overthink
B Too many questions
C We have homework?
D All of the above
What do Most People Around You Think About Their Groups?

a. My group is great. I learn a lot by discussing with them.
b. My group is no help. They are not paying attention.
c. My group is a drag. I do all the work.
d. I’m in a group?
Wheels- no sliding surfaces across each other! So no work, no heating, no wasted energy.

tire

road
1. Why you stop faster in car on snow if don't skid?
2. How to keep from getting stuck in snow.

Friction allows cars to speed up or slow down. Car tires exert force on road ... road exerts force on tires. When tires “glued to the road”, have control.

Friction always opposes motion.
If no sliding takes place, what causes the resistance when pulling a heavy load on wheels (at constant speed)?

A

B

C

D
If no sliding takes place, what causes the resistance when pulling a heavy load on wheels?

Surfaces deform. Deformations generate forces against the motion, transform energy to heat.
Rolling is better than sliding

• Rolling: static friction (larger) is controlling. Static friction larger:
  ✓ Turn better
  ✓ Stop faster
  ✓ (also keep control)

• Antilock breaks keep wheels at threshold of sliding --> greater breaking force.
Does rolling always produce less opposing force than sliding?

YES
A the surface doesn’t matter

B

NO
C depends on the surface

D
Hook’s Law, Springs

Relaxed Spring

Pull down on spring with 2N (0.45 lbs) of force

Spring stretches X meters.
Relaxed Spring

Pull down on spring with 2N (0.45 lbs) of force

Spring stretches X meters.

How much would it stretch if pull down on spring with force of 6 N?

a. same distance as for 2 N force  
b. 2 times as far  
c. Between 2 and 3 times as far  
d. 3 times as far  
e. More than 3 times as far

Answer is d. 3 times as far
Relaxed Spring

Pull down on spring with 2N (0.45 lbs) of force

Spring stretches 1 meter.

How much would it stretch if pull down on spring with force of 6,000,000 N (about as much as a steam engine)?

A 3,000,000 m
B it will break
C it will contract

Applying Hooks law gives 3,000,000 m, but Hook’s law is only valid for small deformations.
Data says the larger the mass (or force down), the further the spring DEFORMS, and these are proportional ... 2 times the force, 2 times the stretch ... 3 times, 3 times, ... etc.

\[ F_{\text{spring}} \text{ pulls up on mass} \]
\[ F_{\text{spring}} \text{ balances weight} \]

\[ F_{\text{gravity}} = \text{weight} = mg = 0.2 \text{ kg} \times 9.8 \text{ m/s}^2 \]

Means that \( F_{\text{spring}} = \text{constant} \times \text{distance stretched} \).

HOOK's LAW: \[ F_{\text{spring}} = -kx \]

Constant = \( k \)
Is the "Spring Constant"

Minus says that force is in opposite direction to DEFORMATION.
The larger the stretch (\( x \)), the larger the force of the spring pulling up!
Scale relates $x$ to weight

When these spring force balances gravity force so that the net force is 0 and the mass is stationary, we say the mass is in equilibrium.

In equilibrium,
\[ F_{\text{net}} = 0 \]
\[ F_{\text{net}} = mg - kx = 0 \]
So, \( mg = kx \)

So if you have a spring and measure the value of \( k \), then you can hang any weight on it, and from \( x \) can calculate the weight = \( kx \).
What about if squashing the spring? How much would it compress if we placed 0.2 kg mass on top of it spring?

a. x squash smaller than x hang
b. they are about the same
c. x squash bigger than x hang
d. I still haven’t figured out the buttons on my clicker.

Answer is b. Compression distance about the same as the stretch distance. $F_{\text{spring}}$ must still balance same weight, mg.

$kx = mg$

$k$ is same for compression or stretch
Trucks, cars, mountain bikes are held up by springs to reduce feeling of bumps

A truck weighs 2000 kg. The weight is equally distributed: 500 kg on each of the four wheels.

The truck’s suspension springs are 0.3 m inside the truck.

When fully loaded (with 250 kg on each of the back wheels), the back of the truck drops 0.1 m

How long are the springs when outside the truck?

- a) 0.2 m
- b) 0.3 m
- c) 0.4 m
- d) 0.5 m
- e) 0.6 m

Adding 250 kg makes springs 0.1 m shorter, so
Removing 500 kg makes springs 0.2 m longer.

Relaxed length = 0.3 m + 0.2 m = 0.5 m
Motion in 2 Dimensions

We can separate motion in two (arbitrary) PERPENDICULAR axes. We can consider motion independently for EACH axis.

**X-axis**

\[ V_x = v_{0x} + at \]
\[ x = x_0 + v_{0x} t + \frac{1}{2} a_x t^2 \]

**Y-axis**

\[ V_y = v_{0y} + at \]
\[ y = y_0 + v_{0y} t + \frac{1}{2} a_y t^2 \]
In circular motion, acceleration is always perpendicular to the velocity.

\[ a_c = \frac{v^2}{R} \]

\[ F_c = \frac{mv^2}{R} \]

\[ S = R \theta \]

\[ v = R \omega \]

\[ \omega = \text{angular velocity (eg. degrees/sec)} \]