Springs and Stomachs
or
Why Your Stomach Feels Like #*&%@?! When in Free Fall

Hold a slinky at least 5-6 ft off the floor (stand on a chair, stepstool, or table if necessary), with enough of the coils held in your hand so that there are about 2-3 ft of coils hanging freely downward from your hand. Then drop the entire slinky. Note that as the slinky falls it does not stay stretched -- the stretched coils come together.

Galileo's discoveries at the Leaning Tower of Pisa led us to realize that if both a light object and a heavy object fall toward the earth under the influence of the force of gravity alone (i.e., air resistance and any other forces either absent or so small as to be negligible) the objects will fall with the same acceleration.

Since air resistance is not really a significant factor with the falling spring, it might be easy to fall into the trap of expecting all parts of the stretched spring to fall with the same acceleration. But this ignores the fact that when the spring is stretched, the lower portion feels a "stretch force" **UPWARD**, and the upper part feels a "stretch force" **DOWNWARD**.

The stretch force acting **DOWNWARD** on the **TOP** part of the spring combines with the force of gravity to give a **LARGER** net force than gravity alone, and thereby causing the **TOP** portion of the spring to have a **LARGER** acceleration than an object in normal free fall under the influence of gravity alone.

The stretch force acting **UPWARD** on the **LOWER** part of the spring opposes the force of gravity, making a **SMALLER** net force than gravity alone, and thereby causing the lower part of the spring to have a **SMALLER** acceleration than an object in free fall under the influence of gravity alone.

Since the upper part of the spring falls slightly **FASTER** than an object in normal free fall, and the lower part falls slightly **SLOWER** than an object in normal free fall, the **TOP** of the spring **CATCHES UP** with the **BOTTOM**, causing the spring to come together. As the coils of the spring come together, however, the stretch force gets smaller, and the top doesn't catch up with the bottom as rapidly. If the spring can fall far enough before hitting the floor, the top will eventually catch up with the bottom. When this happens, the stretch force is zero, and the spring falls the rest of the way to the floor with all parts having the same constant acceleration as any freely falling object.

Figure 1 shows a wooden bar with a balloon attached to its underside, a mass suspended from it by rubber bands, and a sharp-pointed screw pointing upward from the top of the mass. Figure 2 shows a closer view of the assembly, without the balloon.

Drop the assembly (with the balloon in place) from a height of 4 or 5 ft. In free fall, the stretched rubber bands will contract just like the slinky did, causing the wooden bar and balloon to fall faster than the mass. When the balloon overtakes the mass, the contact with the sharp point pops the balloon. Notice that this happens almost immediately. CAUTION: Dropping the assembly on a hard floor may damage it. Consider dropping it onto a pillow, jacket, or other soft object, to cushion its impact.

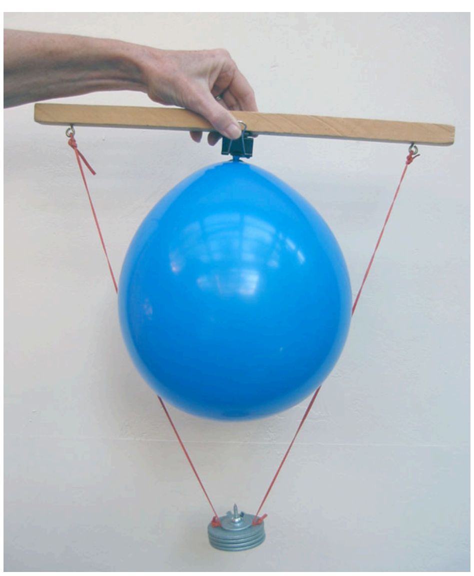

Figure 1

Figure 2

NOTES FOR MATERIALS AND CONSTRUCTION DETAILS:

• mass used here is a collection of steel washers held together by a machine screw and wing nut -- most of the washers were hot-glued together to make them a more cohesive unit and keep them from sliding around

• the point on the machine screw was obtained by grinding with a bench grinder

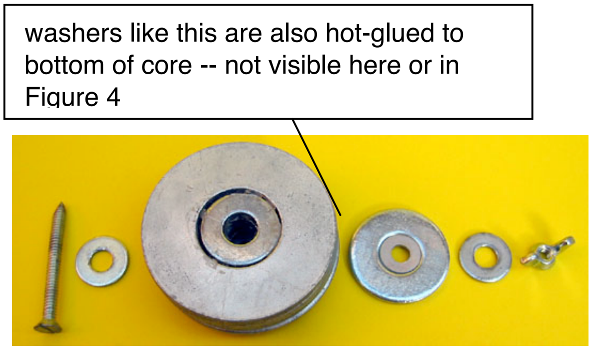

Figure 3

Figure 4

• you can substitute a reasonably large round lead fishing weight, and a push pin for the washer assembly and sharpened screw -- use two screw eyes screwed into the lead weight to provide places to tie the rubber bands -- drill a hole in the weight for the plastic head of the push pin, and fill with hot glue after the head is inserted

• whether you use the masses described here, or improvise your own, you will likely have to do some trial-and-error experimenting to get a combination of rubber band stretch and mass that works consistently

• the balloon is held by a binder clip that is in turn held to the wooden bar by adhesive-backed velcro pieces attached to it and to the bar

• this demonstration draws its inspiration from a NASA publication: see "Free Fall Demonstration" in the NASA publication "Microgravity," EG-103, 1995.

If the same demonstration is done using string instead of rubber bands, everything falls with the same acceleration right from the beginning, and the balloon will not pop until it hits the sharp point when everything reaches the floor.

So what does all this have to do with your stomach? Well, let's compare your stomach to the mass. Normally the mass is held in place by the stretched rubber bands. Your stomach is normally held in place in your body cavity by stretched musc1es. In the same way that the mass comes into contact with the balloon in free fall, your stomach in free fall finds itself in a position in your body cavity that it does not usually occupy. This abnormal situation is registered by the brain, triggering the physiological responses that make your stomach feel different in free fall. When you reflexively tense your abdominal muscles on rides, you are actually attempting to lessen this effect by holding the stomach in its normal place.