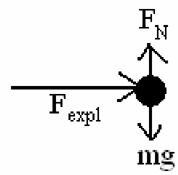
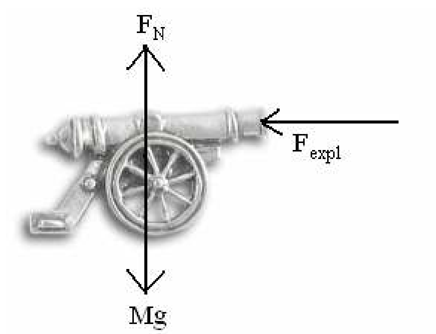
Consider a cannon and a cannonball. We know that the net force acting on a cannonball after the cannon is set off is clearly not zero. Would you want to stand in front of a cannon as it fires? Of course not! The ball comes out at an incredible rate of speed, having attained a large momentum as a result of the explosion. This gets back to possibility #1 from the powerpoint. A non-zero net force on the ball produces a huge change in its momentum.



Viewing the cannonball on its own as the explosion occurs, a net force acts in the horizontal direction (the normal force from the cannon's barrel and the weight of the ball cancel one another in the vertical direction.

But what is happening from the point of view of the cannon? Newton's 3rd Law tells us that the force applied to the cannonball will have a counterpart, exactly equal and opposite, which acts on the cannon. What is the result? Any who have watched closely when a cannon fires (in real life or in the movies) have noticed that the cannon recoils, sliding backwards after the explosion. Again, a non-zero net force on the cannon changes its momentum.



That's all well and good, but what does this have to do with <u>conserving</u> momentum? How can there be any conservation at all when we just argued that momentum was changing all over the place? As with a lot of problems we've encountered, it's all a matter of perspective.

Let's try this: think of the cannon and the cannon ball together as one entity, or as we often call it in physics, a *system*. We know very well that the cannon and the cannon ball interact with one another, exchanging forces before and during the explosion, but if we choose to remain ignorant to exactly what happens between the two and consider only what happens to them as one unit externally, we can gain some understanding about what occurs.

Ask the students to draw the forces acting on the cannon and cannon ball as a single system. Neglecting friction, the only forces that they should come up with are the weight of the cannon/ball combination and the normal force of the ground acting upward. Of course, these two forces cancel one another, and $F_{net} = 0$ on the system. What does this imply? The momentum of the system must be conserved!

Since the total momentum is zero before the explosion occurs, the total momentum after the explosion must remain zero. Most students immediately make the connection that the "forward" momentum of the ball is exactly balanced by the "backward" momentum of the cannon. Although the ball moves at a much higher speed than the cannon, the cannon's larger mass makes this possible ($mV = Mv$).