# Chapter Seven – Newton's Third Law

I hope you have noticed that Newton's Third Law has already been talked about in class. In particular, the force measured by a scale, the thing we call weight, is the reaction to the normal force of the scale pushing up on the person or thing being weighed.

The action-reaction law does reinforce the point that "real forces" are interactions between two objects since an action-reaction pair of forces are forces acting on each of the two objects that cause the forces in question. For example, a book feels a force of friction as it slides across a table. That is a force acting on the book and caused by the table. But there is an <u>equal and opposite force</u>, the other half of the action-reaction pair, the friction force acting on the table caused by the book.

The most egregious error made by beginning physics students is to misidentify the pair of forces involved in an action-reaction pair. Going back to the book sliding on the table, gravity pulls down on the book and a normal force pushes up on the book. <u>Those forces are equal and opposite but are not an action-reaction pair!</u> First, both forces act on the same object while action-reaction forces <u>ALWAYS</u> act on different objects. An action-reaction pair of forces acts on the pair of objects that are the cause of the forces in question. The weight of the book is caused by the gravitational tug of earth, not the upward push of the table! Therefore the reaction force that pairs with the book's weight is the tug on earth caused by the book. This reaction force is usually totally irrelevant in solving problems but ought to be kept in mind to avoid the common error described above. ***To summarize, an action-reaction pair of forces are <u>always</u> equal and opposite, but two forces that are equal in magnitude and opposite in direction are <u>NOT</u> always an action-reaction pair!***

On the other hand, the reaction force to the normal force pushing up on the book is the force of the book pushing down on the table. This pair of action-reaction forces can be useful in solving a problem. Remember a scale measures the reaction to the normal force required to keep the object being weighed from accelerating toward the center of earth!

I did not find the "interaction diagram" introduced in this chapter very useful and will not use it solving problems. But if you find the textbook's problem solving strategy helpful, I encourage you to use their strategy. Instead I will try to emphasize the utility of free-body diagrams.

Much of the rest of the material in this chapter has less to do with identifying action-reaction pairs of forces than with developing good problem solving skills. For example, the section **Acceleration Constraints** points out that in some problems different objects, connected in some manner, may have accelerations with equal magnitudes in the same or different directions. Recognizing when this is the case is very important because it reduces the number of unknowns in that problem by one. For example force $F_1$ acts on mass $m_1$ causing an acceleration $a_1$ and force $F_2$ acts on mass $m_2$ causing an acceleration $a_2$ but the objects are connected in such a way that $a_1 = a_2$. Then $a_1$ and $a_2$ can be replaced by a common value, a, eliminating one of the unknown quantities.

This chapter also points out the simplification caused by having "massless" ropes and "massless and frictionless" pulleys. Under those special circumstances, the tension in a rope is constant along its length. This means that if a fish scale is inserted anyplace along the length of the massless rope, the fish scale will read the same tension. Of course if the rope is not massless, then the tension will vary along the length of the rope. Also if the pulley is turning with a constant angular velocity and is not frictionless, the tension will be different on each side of the pulley. Finally if a frictionless pulley has mass and connects accelerating objects, the magnitude of the tension in the rope passing over the pulley will be different on each side of the pulley.

In dealing with problems involving ropes and pulleys, my assumption is that the ropes are massless and the pulleys are massless and frictionless unless the problem explicitly states otherwise! By that I mean that the mass of the rope and/or pulley will be given and/or some value of the inherent friction for the pulley will be given. Ropes and pulleys with these simplifying properties are called ideal ropes and pulleys. Absent explicit information to the contrary, I always assume that the ropes and pulleys are ideal.

Do as many problems as you can in this chapter. The problems offer you the opportunity to review the important concepts introduced in earlier chapters.