Homework 7.

Third Newton's law

During last class we have discussed another interesting property of our world. It can be simply formulated as follows: every time one object applies force to another object, this "another" object applies force to the first object. The forces have equal magnitudes and opposite directions.

For example, imagine that you try pushing a heavy 20 kg stone while both you and the stone are on ice. You push the stone with a force of 80N. What happens next?

Both you and the stone will slide in opposite directions. What is acceleration of the stone while you are pushing it? It is simple to calculate it:

$$a_{stone} = \frac{F}{m} = \frac{80N}{20kg} = 4\frac{m}{s^2}$$

What about your acceleration? Assume that your mass is 40kg. But what about force which made you slide? Its magnitude is equal to the magnitude of the force you applied to the stone, but it is directed oppositely. It looks like the stone pushed you with the same force of 80N:

$$a_{you} = \frac{F}{m} = \frac{80N}{40kg} = 2\frac{m}{s^2}$$

So your acceleration is be smaller, because your mass is higher and the magnitude of the forces applied to you and the stone are same.

This "picture" is universal. Whenever you apply force to something this something applies force of equal magnitude and opposite direction to you. *These forces do not compensate each other because they are applied to different objects.* We know that we can add and subtract only the forces applied to the same object.

Now we learned three laws which are the base of simple mechanics:

1. The object in motion tends to stay in motion; an object at rest tends to stay at rest.
2. The total net force applied to an object is equal to the mass of the object multiplied by the acceleration of the object.
3. Any time a force is applied by one object to another, a force of same in magnitude and opposite direction is applied to the first object by the second one.

These laws are called Newton's laws of motion.

Problems:

1. A slightly compressed very light coiled spring is released and pushes two carts in opposite directions (see figure below). The carts are different. After the spring is fully stretched the left cart has a velocity of 4cm/s and the right cart has a velocity of 60cm/s. Which cart has higher mass and how many times this mass is higher than the mass of the other cart?

2. Assume that the mass of the right cart is 50g. What is the mass of the other cart? (Use data of the problem 1)

3. Your boat is approaching the riverbank and you are ready to jump to the ground. In what case it will be easier to do that:

a. your boat is empty

b. your boat is heavily loaded?