Collisions: What Weight Car Will YOU Drive?
An Applied Physics Question
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1 Questions

By the end of this lab session, here are some questions you should know the answer to:

1. What is physics? What kind of questions can it answer? What kind of work might a physicist do?
2. What is a force? Name some forces.
3. If I push on you, and you push back on me, which one of us is pushing harder?
4. What is acceleration? deceleration?
5. How are mass, acceleration, and force connected?
6. If you were planning a transportation system, and wanted to save fuel and have people safe, what kind of cars would you use?
7. What is momentum and what does "conserved" mean?

2 What will we do?

In this lab we will try some collisions, first with marbles, and then with cars. Keep notes, try to guess what will happen, then see what does happen.

1. Take your physics textbook (finally something useful for it!). Put it on the table. Put your marbles in the indentation of the spine of the textbook. (Gently) push one marble against the other(s). Start with a pair of same size marbles. Then try having the target group be 2,3 or 4 marbles.

2. When you are sure about what happens with same size objects, check the results with different size marbles. Use the small marble as a target, let the large marble hit it.

3. Now use the large marble as a target, let the small marble hit it.

4. When you think you can describe marble collisions, ask for a set of cars, and see if the same sorts of things happen with cars.

3 Ideas about the Questions.

Below are some notes to help you start thinking about the answers to the questions.

QUESTION: HOW ABOUT GIVING THEM THE QUESTIONS AHEAD OF TIME, AND THE WHOLE SET INCLUDING ANSWERS AT THE END? OR JUST GIVE THEM THE WHOLE SET OF NOTES AHEAD OF TIME?

3.1 What is Physics?

Physics is about how things work, both on large scales, like collisions, and on the tiniest scales, like atoms, electrons, neutrons, protons. It is about forces, and what causes things to move. Electrical forces on atoms and electrons and other particles are behind many of the fancy medical diagnostic and treatment tools we have now (MRI, CT scan, X-rays, Particles delivering radiation for cancer treatment, etc). Physics is about rainbows and light and baseballs and TV's and computers and video games. Maybe that's enough for a start.

3.2 What is a force?

A force is always present if an object CHANGES its motion.. either how fast it is going, or its direction. If an object does not change its motion, then either no force is acting on it, or the vector sum of all forces acting on it is zero.

Some forces are:

1. push or pull from "contact force" (normal pushes, pulls, ...)
2. frictional forces (which give us traction, also lose energy to heat...)
3. gravitational forces (keeps us on the earth and the earth going around the sun...)
4. electrical and magnetic forces (besides lights and radios and TV's, these are also responsible for friction and for holding us together, allowing the pushes and pulls described above).

5. nuclear forces (nuclear power, fusion which keeps the sun burning,...)

6. "weak" force (eg, radioactivity)

3.3 Who pushes harder?

Turns out that if two people push on each other, the two forces are equal and opposite. BUT they act on different objects (say, if you push on me, your push acts on me but my push back acts on you). So, in order not to move under the push I give you, there must be some other force pushing back... usually that is some frictional force.

Notice that to find out what happens to a given person, you need to add up all the forces acting on that person... If you push on me and I am standing on the ground, a frictional force between me and the ground pushes back, and I don't move. If, however, I am standing on ice, or on wheels, there is almost no friction, and I will move, since, approximately, only the force from you is acting on me.

3.4 How are mass and weight connected?

Mass, the amount of material in an object, can be defined and used anywhere. Weight is the force exerted by an object near the surface of the earth.

3.5 What is acceleration? deceleration?

Acceleration is the rate at which a velocity (or, in one dimension, a speed) changes. Deceleration is negative acceleration: that is, the speed is decreasing. In a collision between two cars, each car decelerates until it comes to a stop. In our model of the collision, the cars come to a stop when their engines touch. Bigger deceleration means the cars stop sooner.

3.6 How are mass, acceleration, and force connected?

$$F = ma$$

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3.7 What to do?

If you were planning a transportation system, and wanted to get good gas mileage and have people safe, what kind of cars would you use?

Since forces are equal and opposite, and F = m a, if cars are of approximately equal weight, then their accelerations will be approximately equal: no lopsided decelerations. If cars are of unequal weights, one car will have a severe deceleration, the other only a small one.

The larger the distance a car has to stop in, the less acceleration is needed to stop it.

The lighter the weight (mass) of a car, the less energy (fuel) it takes to move it.

All the above, combined, suggest strong but light cars, relatively large for the mass (weight) of the car.

3.8 What is momentum and what does "conserved" mean?

From F=ma, and remembering that acceleration is the change in velocity divided by the change in time, we see that F = m (del V/del time). In this case since the speed is decreasing, the acceleration is negative; another way to say this is that there is deceleration. So F del time = m del v. If the time is vanishingly short (as in a collision or explosion), or if no outside forces act, the F del time is ZERO, and the quantity mv is conserved. We call this quantity momentum. Some examples are: two objects, one hits the other. The total momentum of the two objects before the collision is the same as afterward (momentum is "conserved"). In the activity we will let the students collide marbles, and they will be able to see that for equal masses, the speed of the outgoing marble is about the same as for that coming in. We will also have some cars of different sizes/masses, and students will be able to see a light car rebound and a heavy one continue to carry both it and a lighter one forward.

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