6B Newton's Third Law

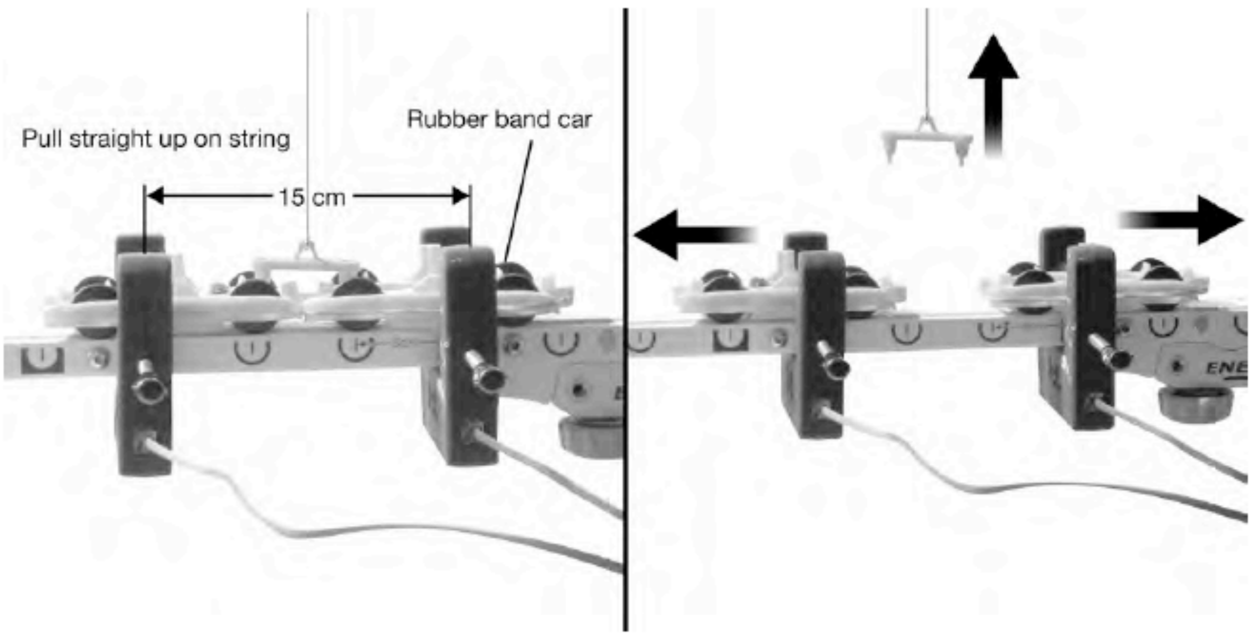
What happens when equal and opposite forces are exerted on a pair of Energy Cars?

When you apply a force to throw a ball you also feel the force of the ball against your hand. That is because all forces come in pairs called action and reaction. This is Newton's Third Law of motion. There can never be a single force (action) without its opposite (reaction) partner. Action and reaction forces always act in opposite directions on two different objects. You can set up two Energy Cars to study Newton's Third Law.

Materials

- Energy Car
- Data Collector and photogates
- 1 Rubber band
- 2 Steel marbles
- Energy Car Link

1 Setting up and starting the experiment



1. Set up the long straight track with a ball of clay on each stop. Use the bubble level to set the track level.
2. Place one steel marble in each car, and wrap one car with a rubber band.
3. Place two photogates 15-cm apart as shown in the photo.
4. Place the 2 cars, "nose to notch" between the photogates.
5. Squeeze the cars together and attach them with the Energy Car link.
6. Center the attached car pair between the photogates so each is about to break the photogate's beam, but do not actually break the beam. Check that both photogate indicator lights are still green. Make sure all 4 wheels of both cars are on the track.
7. With a *very quick* upward motion, pull the link *straight up* and out from the cars. ***CAUTION: Wear eyeglasses or safety glasses to avoid injury.***
8. Observe the time through each photogate. Repeat several times.

2 Thinking about what you observed

a. What caused the two cars to move when you took out the link?

____

____

____

b. According to Newton's third law, the cars experienced equal and opposite forces. How can you tell this is true by looking at the time through each photogate?

____

____

____

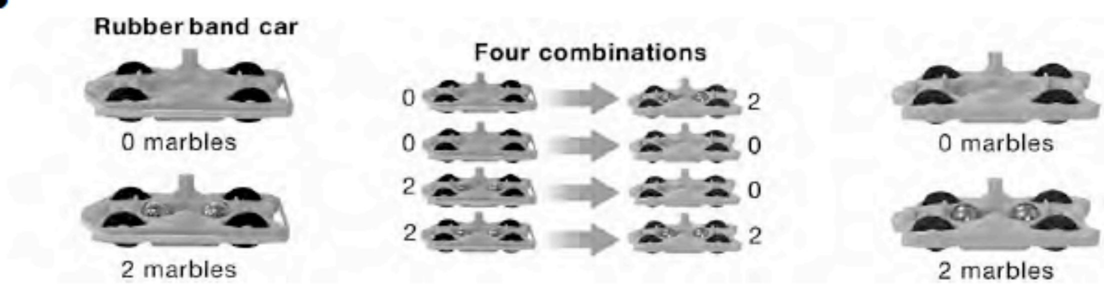
c. If one car was twice the mass of the other, would the cars still experience equal and opposite forces? Why or why not?

____

____

____

3 Changing the masses



NOTE: Adding two steel marbles to the Energy Car doubles its mass.

1. Try the experiment with the four combinations of mass shown above. Take the average of three trials for each and record your data in Table 1. ***CAUTION: Wear eyeglasses or safety glasses to avoid injury.***

2. Calculate the average speed for each trial and record in Table 1.

Table 1: Energy Car Action–Reaction Data

Marble pairings for connected cars		Time through photogate (s)		Speed (cm/s)	
A	B	A	B	A	B
0 marbles	2 marbles				
0 marbles	0 marbles				
2 marbles	0 marbles				
2 marbles	2 marbles				

4 Applying what you have learned

a. How does the speed of each car pair compare when masses are equal?

b. How does the speed of each car compare when one of the pair has twice the mass?

c. Explain how your speed data supports the idea that there are equal and opposite action and reaction forces acting on the cars.

d. If the action and reaction forces are equal in strength, when the cars separate, why does one car move at a different speed than the other car when the masses are unequal? Hint: the answer involves the second law of motion.