***Name*____________________________**

Momentum and Elastic Collisions

A. **Your group will be assigned one of the three collisions [I]-[III] on the back of this worksheet. Discuss (1)-(2) below and then put your group's answers on a separate sheet.**

1. Use the following generalized procedure to determine what happens in the final state of your collision:

(a) Find the magnitude (in "massless" cm/s units) and direction (left/right) of the initial momentum vectors of the *two balls*.

(b) Find the magnitude (in "massless" cm/s units) and direction (left/right) of the initial momentum vector of the *system*.

(c) Find the magnitude (in "massless" cm/s units) and direction (left/right) of the final *momentum* vector of the *system*, assuming that *total momentum of the system* is conserved.

(d) Find the magnitude (in "massless" cm/s units) and direction (left/right) of the final momentum vectors of the *two balls*.

(e) Find the magnitude (in cm/s) and direction (left/right) of the final velocity vector of ball *B*. *(You may check your final velocity directions by actually colliding them.)*

B. **When is momentum conserved? Discuss (3)-(6) and then record your answers (with brief explanations) on this sheet.**

3. When Newton's $\begin{bmatrix}\text{First Law}\\ \text{Second Law}\end{bmatrix}$ applies to an object, its momentum is conserved.

4. When Newton's $\begin{bmatrix}\text{First Law}\\ \text{Second Law}\end{bmatrix}$ applies to a *system* of objects, their total momentum is conserved.

5. In the collisions [I]-[III], Newton's $\begin{bmatrix}\text{First Law}\\ \text{Second Law}\end{bmatrix}$ applied to ball *A*.

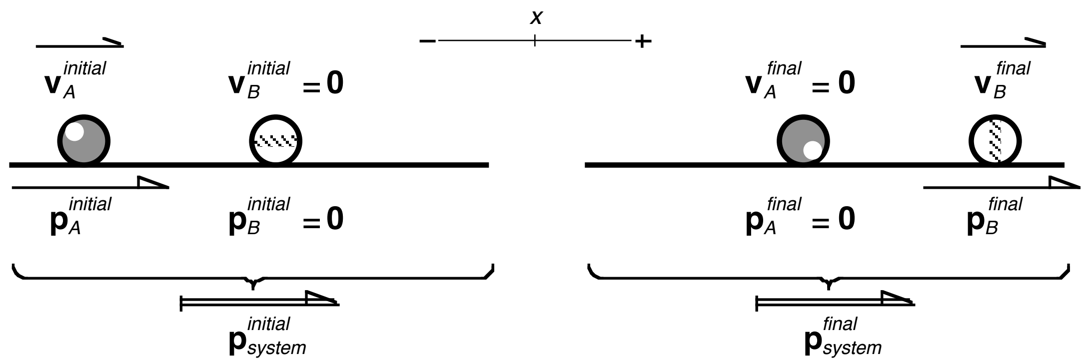
Explain why this is so, according to the given information!

6. In the collisions [I]-[III], Newton's $\begin{bmatrix}\text{First Law}\\ \text{Second Law}\end{bmatrix}$ applied to the system of ball *A* and ball *B*. **Explain why this is so, according to the given information!**

This activity splits up the work among the different groups, in order to move things along, as the conservation calculations get quite repetitive and tedious.

The directions (and approximate relative magnitudes) of the velocity and momentum vectors are shown below for collision (I), along with a spreadsheet (± denotes direction along the *x*-axis) for each collision (I)-(III). Note that the masses that were given were in relative units; FYI the billiard ball is approximately 158 grams, and the golf ball is approximately 45.5 grams, *but students do not use absolute mass values here*.

Collision [I]: bb into bb:



Collision [I]: bb into bb:

mA	1	mB	1					
initial					final			
vA	50	vB	0		vA	0	vB	50
pA	50	pB	0		pA	0	pB	50
pto t	50				ptot	50		

Collision [II]: gb into bb:

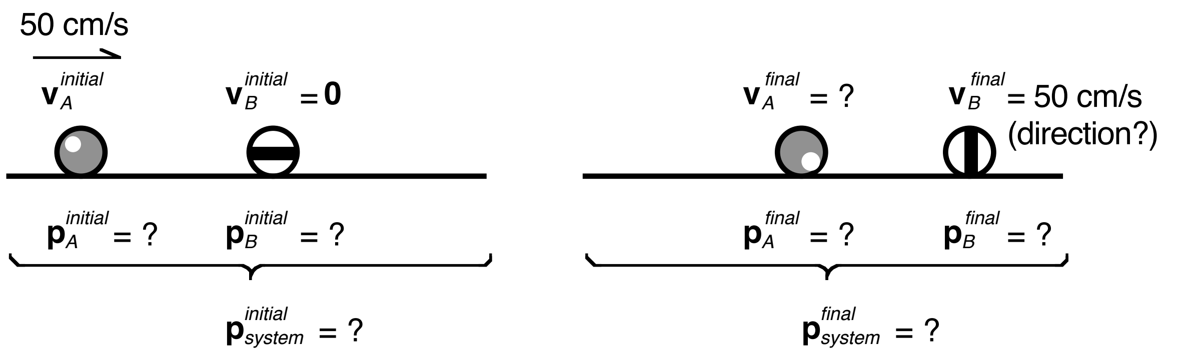
mA	0.288	mB	1					
initial								final
vA	50	vB	0		vA	–27.640	vB	22.360
pA	14.4	pB	0		pA	–7.960	pB	22.360
pto t	14.4				ptot	14.4		

Collision [III]: bb into gb:

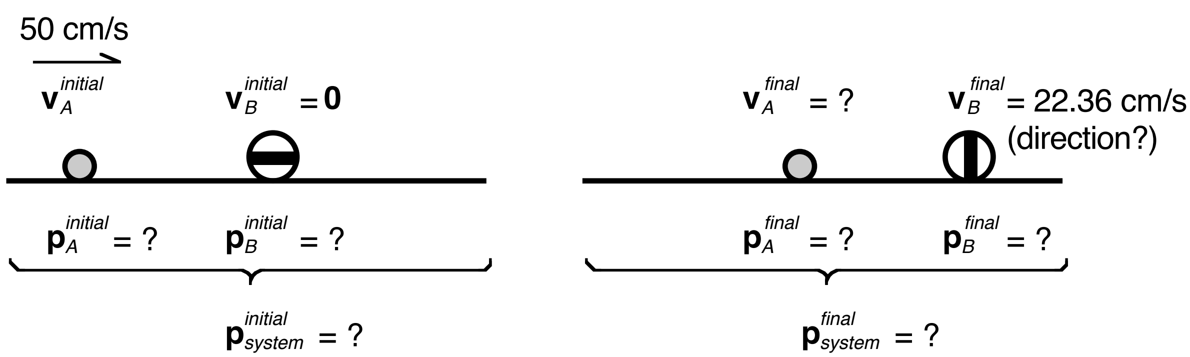
mA	1	mB	0.288					
initial								final
vA	50	vB	0		vA	27.640	vB	77.640
pA	50	pB	0		pA	27.640	pB	22.360
pto t	50				ptot	50		

For your assigned collision (I)-(III), assume that there are no external impulses on these systems of two objects (i.e., no friction nor air resistance). Use total momentum conservation to determine all unknown initial and final momentum and velocity vectors for these collisions.

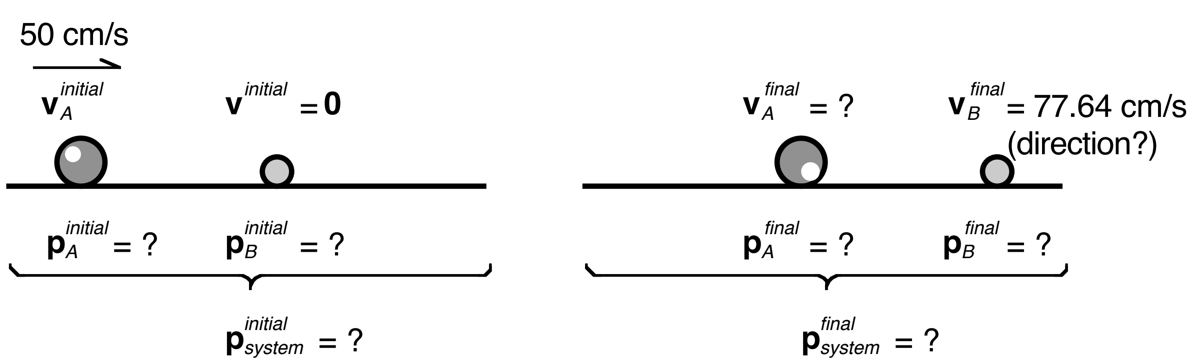
I. A billiard ball *A* slides along a frictionless surface and collides with a stationary billiard ball *B*. Determine the magnitude (in cm/s) of the final velocity vector of billiard ball *A*. These billiard balls have the same mass.



II. A golf ball *A* slides along a frictionless surface and collides with a stationary billiard ball *B*. Determine the magnitude (in cm/s) and direction (left or right?) of the final velocity vector of golf ball *A*. The golf ball has a mass that is 0.288× the mass of the billiard ball.



III. A billiard ball *A* slides along a frictionless surface and collides with a stationary golf ball *B*. Determine the magnitude (in cm/s) and direction (left or right?) of the final velocity vector of billiard ball *A*. The golf ball has a mass that is 0.288× the mass of the billiard ball.



Activity Cycle 10.2.1: TA instructions (continued)

Since realistically there are significant air resistance and frictional forces, the students will have to carefully observe what happens to each ball *just* after they collide (and thus before the effect of external impulses becomes significant). Yet this is not a bad method to *qualitatively* confirm the quantitative momentum conservation calculations of collisions (I)-(III).

2. All three collisions are verifiably elastic (or very nearly so, depending on rounding and truncation of significant figures).

3. When Newton's [First Law] applies to an object, its momentum is conserved.

4. When Newton's [First Law] applies to a *system* of objects, their total momentum is conserved.

5. In the collisions [I]-[III], Newton's [Second Law] applied to ball *A*. **This is because the force of ball *A* on ball *B* <u>is</u> the net force on ball *B*.**

6. In the collisions [I]-[III], Newton's [First Law] applied to the system of ball *A* and ball *B*. **Even though ball *A* exerts a force on ball *B*, and vice versa, you <u>can</u> "cancel them out" because we are treating both balls *A* and *B* in the one and same system, collectively as an "object!"**