A person attempts to knock down a large wooden bowling pin by throwing a ball at it. The person has two balls of equal size and mass, one made of rubber and the other of putty. The rubber ball bounces back, while the ball of putty sticks to the pin. Which ball is most likely to topple the bowling pin?

A. the rubber ball
B. the ball of putty
C. makes no difference
D. need more information

Ch 8.5-6: Center of Mass, Propulsion

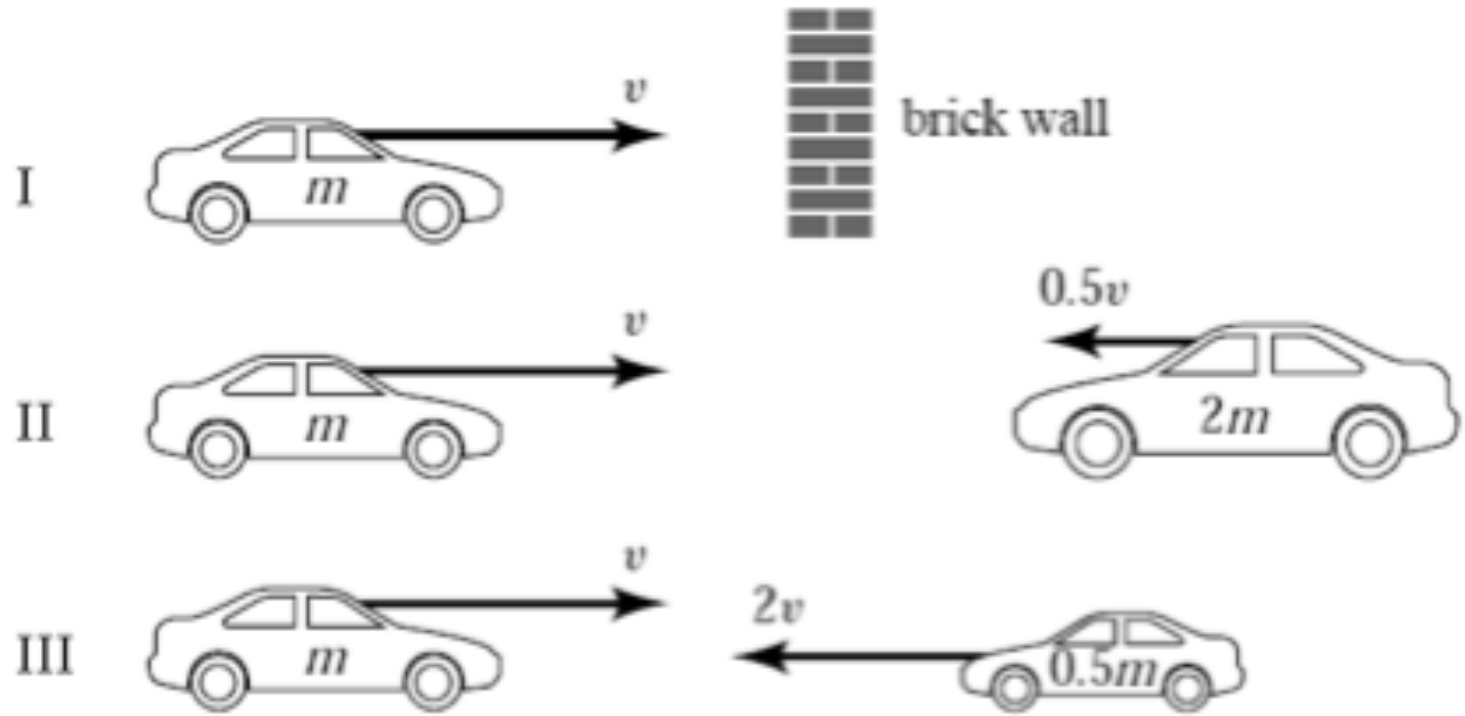
PHYS 1210 -- Prof. Jang-Condell

Goals for Chapter 8

- To learn the meaning of the momentum of a particle and how an impulse causes it to change
- To learn how to use the conservation of momentum
- To learn how to solve problems involving collisions
- To learn the definition of the center of mass of a system and what determines how it moves
- To analyze situations, such as rocket propulsion, in which the mass of a moving body changes

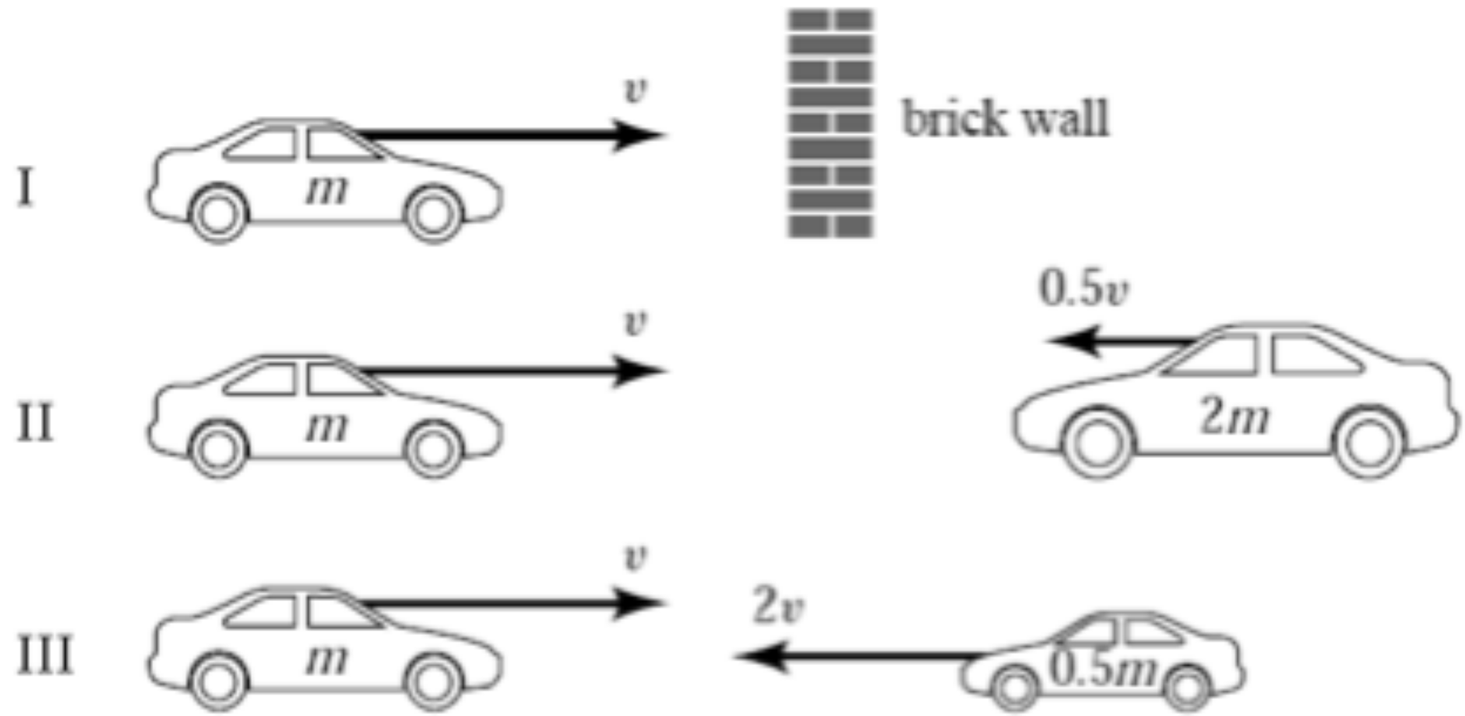
- Full solution to 2D elastic collision problem is on the course website

If all three collisions in the figure shown here are totally inelastic, which bring(s) the car on the left to a halt?



1. I
2. II
3. III
4. I, II
5. I, III
6. II, III
7. all three

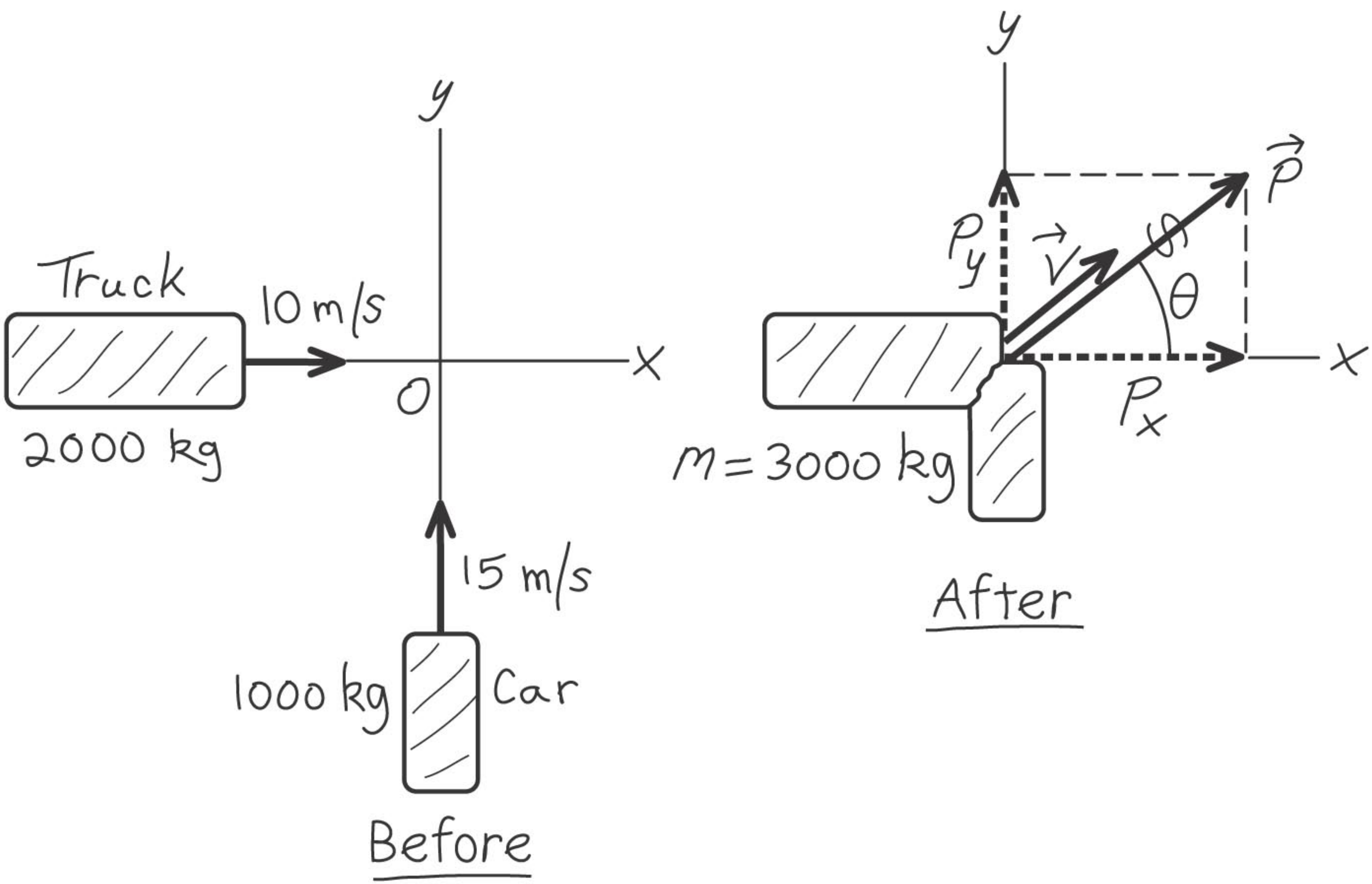
If all three collisions in the figure shown here are totally inelastic, which cause(s) the most damage?



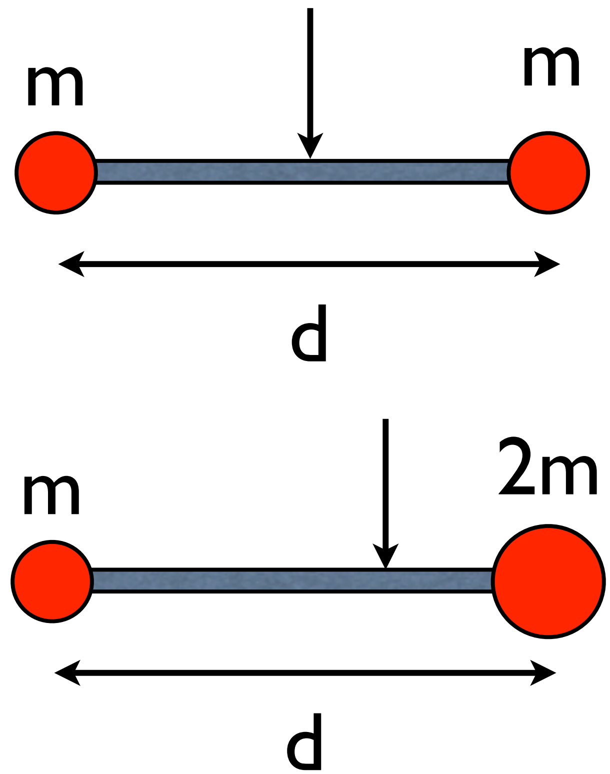
1. I
2. II
3. III
4. I, II
5. I, III
6. II, III
7. all three

An automobile collision

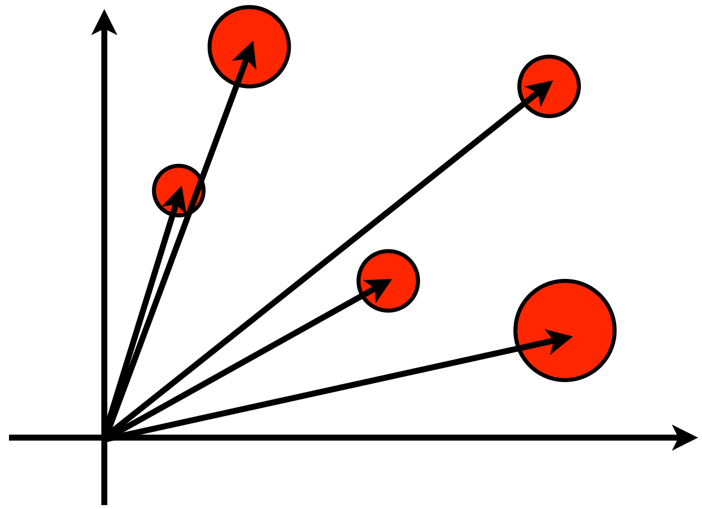
- Example 8.9



Center of Mass

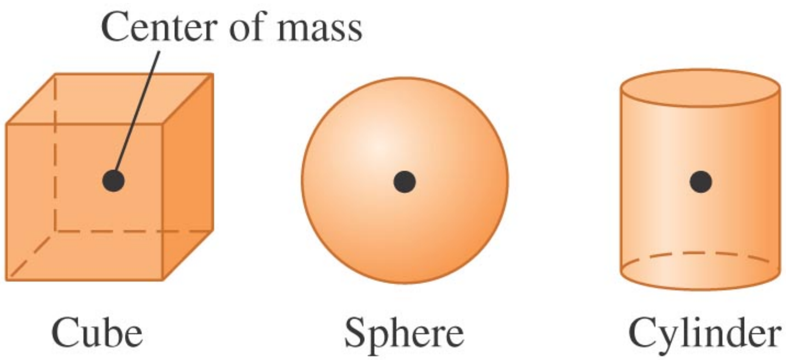


Center of Mass

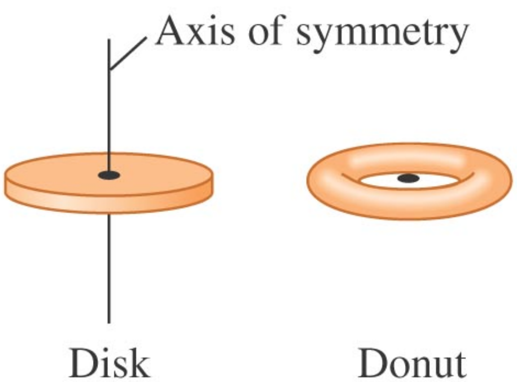


$$\vec{r}_{cm} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2 + m_3\vec{r}_3 + \cdots}{m_1 + m_2 + m_3 + \cdots} = \frac{\sum_i m_i\vec{r}_i}{\sum_i m_i} \quad \text{(center of mass)} \quad (8.29)$$

Center of mass of symmetrical objects



If a homogeneous object has a geometric center, that is where the center of mass is located.



If an object has an axis of symmetry, the center of mass lies along it. As in the case of the donut, the center of mass may not be within the object.

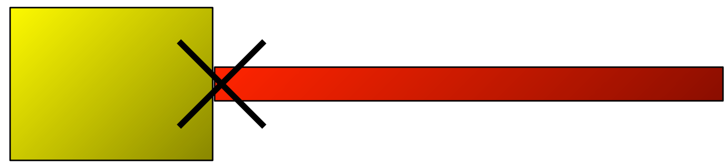
- It is easy to find the center of mass of a homogeneous symmetric object, as shown in Figure 8.28 at the left.
- In general, finding the center of mass of a solid body requires an integral.

Center of mass of combined objects

Q8.9

A yellow block and a red rod are joined together. Each object is of uniform density. The center of mass of the *combined* object is at the position shown by the black “X.”

Which has the *greater mass*, the yellow block or the red rod?



F. The yellow block

G. The red rod

H. They both have the same mass.

I. Not enough information given to decide

Motion of Center of Mass

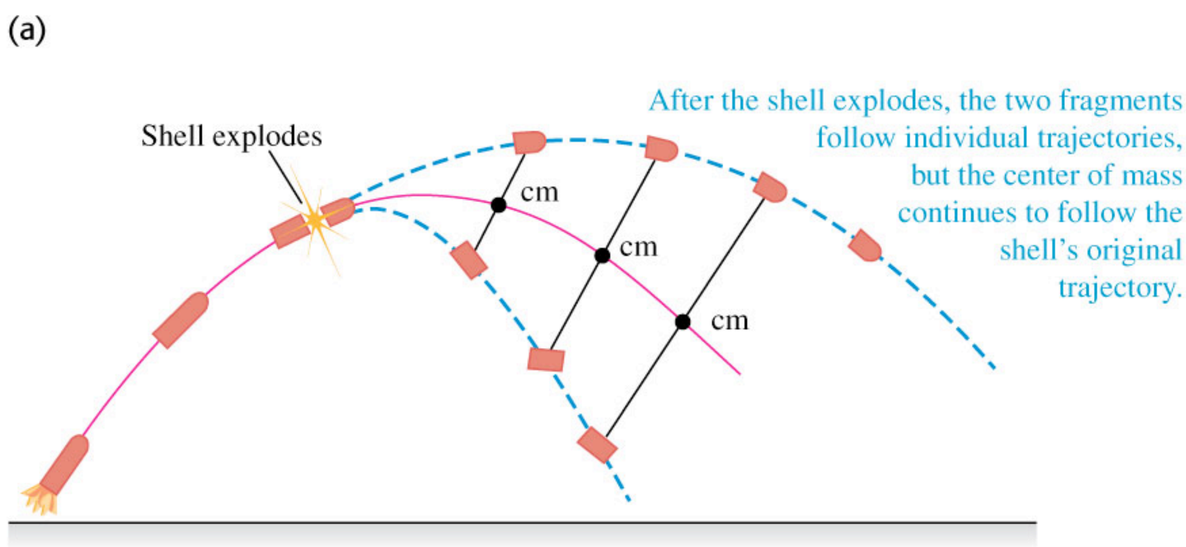
$$\vec{\boldsymbol{P}} = \sum_i \vec{\boldsymbol{p}}_i$$

Motion of the center of mass

- The total momentum of a system is equal to the total mass times the velocity of the center of mass.
- The center of mass of the wrench in Figure 8.29 at the right moves as though all the mass were concentrated there.

External forces and center-of-mass motion

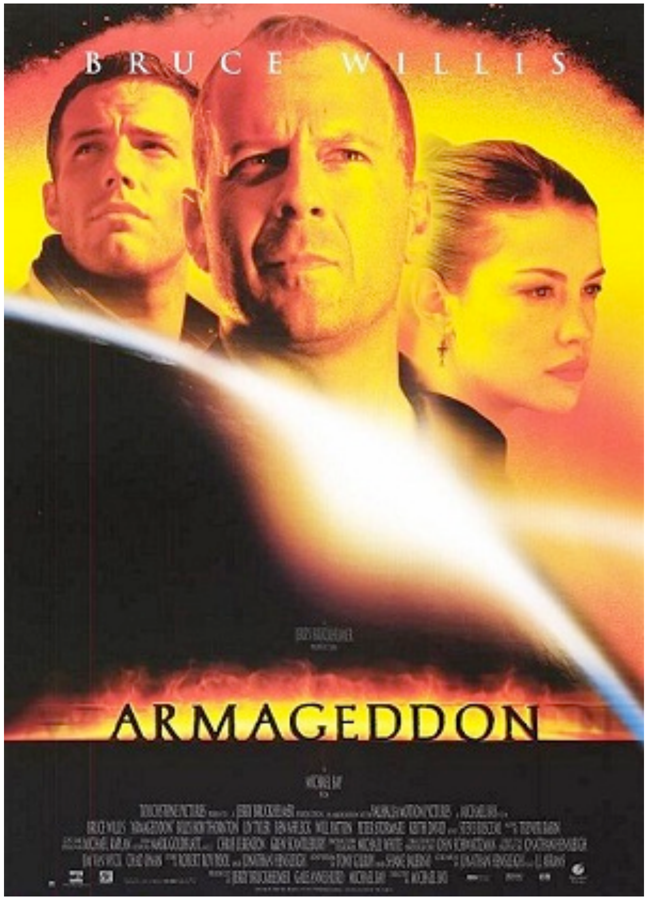
- When a body or collection of particles is acted upon by external forces, the center of mass moves as though all the mass were concentrated there (see Figure 8.31 below).



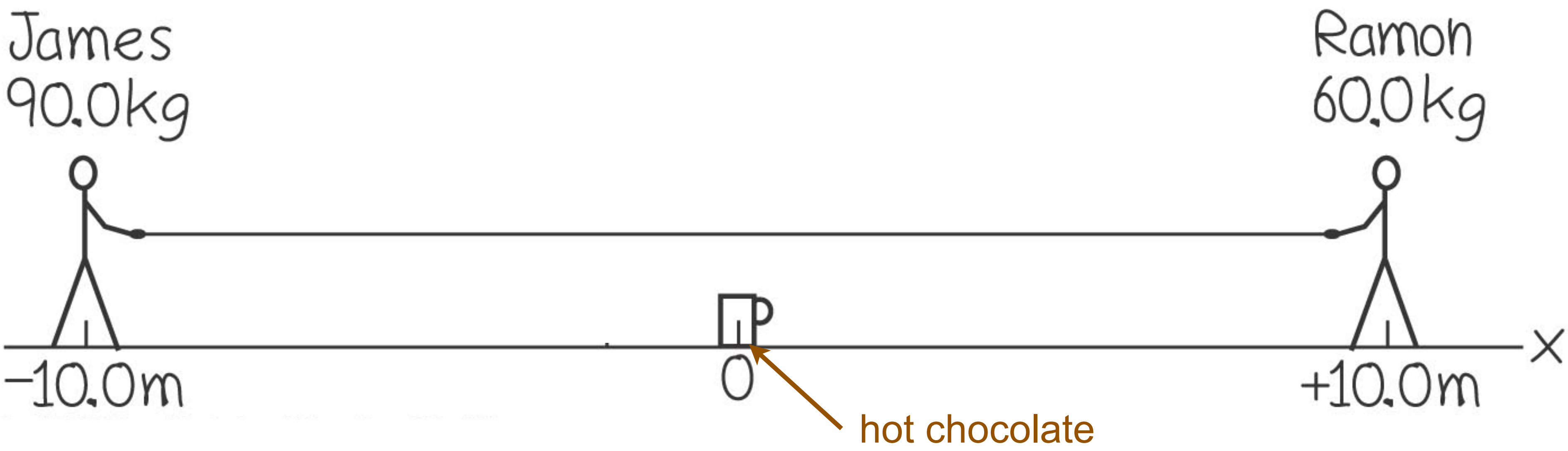
A near-earth asteroid is on a collision course with the Earth!

Is sending Bruce Willis to blow it up a good idea?

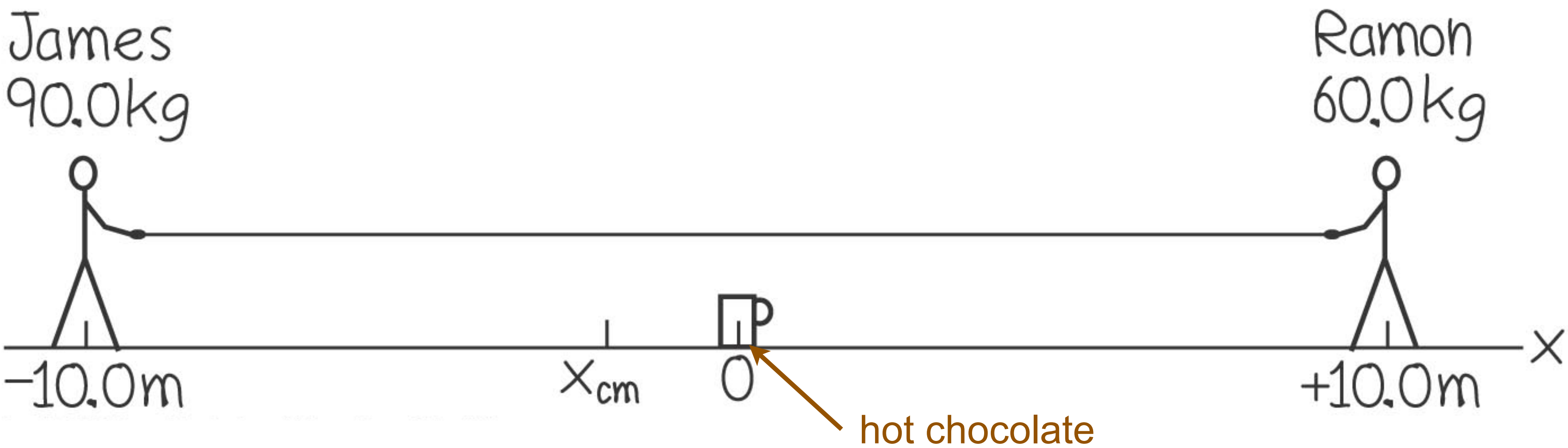
Why or why not?



Tug-of-war on the ice



Tug-of-war on the ice



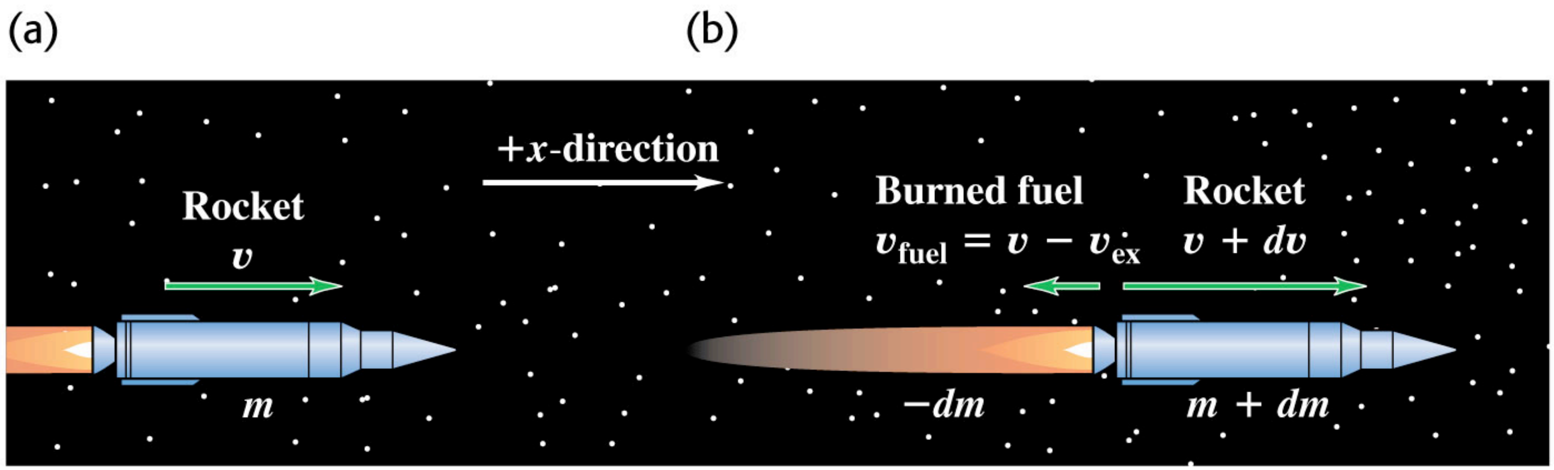
- Who will get to the hot chocolate first?

  K. James
  L. Ramon
  M. Both will get it at the same time
  N. Not enough information to decide.

  Text your answer to 22333.

Rocket propulsion

- How does a rocket move in space?
- As a rocket burns fuel, its mass decreases.



At time *t*, the rocket has mass m and x-component of velocity v.

At time $t + dt$, the rocket has mass $m + dm$ (where dm is inherently *negative*) and x-component of velocity $v + dv$. The burned fuel has x-component of velocity $v_{fuel} = v - v_{ex}$ and mass $-dm$. (The minus sign is needed to make $-dm$ *positive* because dm is negative.)