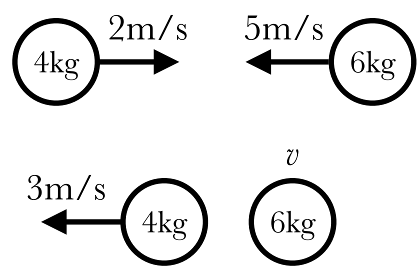
Week 7: Collisions
Additional Homework

Problems (4 points each)

1. A 4kg ball moving at 2m/s to the right collides with a 6kg ball which is moving at 5m/s to the left. After the collision, the 4kg ball is moving to the left at 3m/s.
a. What is the velocity of the 6kg ball after the collision? Is the ball moving to the left or the right?



	horizontal
$\vec{p}_{1i}$	(4kg)(+2m/s)
$\vec{p}_{2i}$	(6kg)(-5m/s)
$\vec{p}_{1f}$	(4kg)(−3m/s)
$\vec{p}_{2f}$	(6kg)v

$$4(+2) + 5(-6) = 4(-3) + 6v$$
$$8 - 30 + 12 = +6v$$
$$v = \frac{-10}{6} = -1.67\text{m/s}$$

b. What is the % energy loss during this collision?

The initial kinetic energy is

$$E_{Ki} = \frac{1}{2}(4)(2)^2 + \frac{1}{2}(6)(5)^2 = 83\text{J}$$

The final kinetic energy is

$$E_{Kf} = \frac{1}{2}(4)(3)^2 + \frac{1}{2}(6)(1.67)^2 = 26\text{J}$$

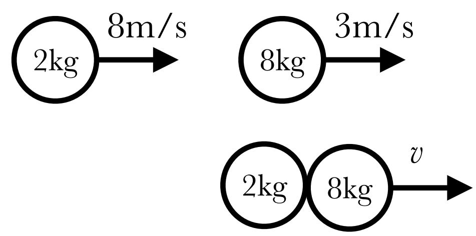
Thus the change is

$$\Delta E_K = E_{Kf} - E_{Ki} = 26 - 83 = -57\text{J}$$

and % Loss = $1 - \frac{26}{83} =$ **69%.**

2. A 2kg ball moving at 8m/s to the right overtakes a 8kg ball which is moving at 3m/s to the right. The two balls stick together.

a. How fast are the balls moving after they stick together?



	horizontal
$\vec{p}_{1i}$	(2kg)(+8m/s)
$\vec{p}_{2i}$	(8kg)(+3m/s)
$\vec{p}_{1f}$	(2kg)v
$\vec{p}_{2f}$	(8kg)v

$p_i = (2)(8) + (8)(3) = 16 + 24 = 40\text{Ns}$

$p_f = 10v$

$10v = 40 \implies v = 4\text{m/s}$

b. How much energy is lost during the collision?

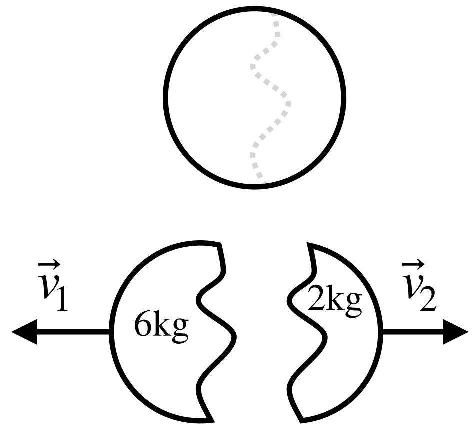
The initial kinetic energy is $E_{Ki} = \frac{1}{2}(2)(8)^2 + \frac{1}{2}(8)(3)^2 = 100\text{J}$

The final kinetic energy is $E_{Kf} = \frac{1}{2}(10)(4)^2 = 80\text{J}$

Thus the change is $\Delta E_K = E_{Kf} - E_{Ki} =$ **−20J.**

This is a 20% energy loss.

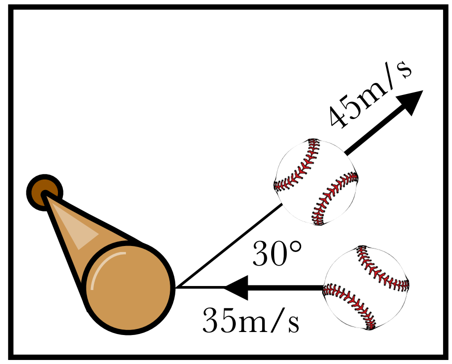
3. An 8kg bomb starts at rest and then explodes and splits into two pieces, a 6kg piece moving to the left with velocity $\vec{v}_1$ and a 2kg piece moving to the right with velocity $\vec{v}_2$. The pieces gain ΔE=300J of kinetic energy due to the explosion.
Find the speeds v_1 and v_2 of the pieces. (Hint: momentum is conserved during the explosion like it is during a collision. Use the formula $E_f = E_i + \Delta E$.



The initial momentum is zero, so the final momentum $-6v_1 + 2v_2 = 0$ as well, which we can write as $v_2 = 3v_1$. The initial kinetic energy is also zero, and the change in energy is 300J, and so the final energy is $E_f = E_i + \Delta E = 0 + 300$, and this is made up of the kinetic energies of the two pieces:
$300 = \frac{1}{2}(6)v_1^2 + \frac{1}{2}(2)v_2^2 = 3v_1^2 + v_2^2$.

Substituting $v_2 = 3v_1$ into this equation gives us $300 = 3v_1^2 + (3v_1)^2 = 12v_1^2 \implies v_1 = \sqrt{\frac{300}{12}}$ =**5m/s**. The speed of the smaller piece is $v_2 = 3(5) =$ **15m/s.**

4. A 140g baseball is struck by a baseball bat when the baseball is moving horizontally at 35m/s. After the ball hits the bat, it is moving at 45m/s, 30° above the horizontal. If the baseball was in contact with the bat for 7ms, what is the average power that the bat provides to the ball during contact? (You can ignore gravitational potential energy, and the power that the baseball bat releases as sound, heat, etc.)



Before contact, the energy of the baseball is $E_i = \frac{1}{2}(0.140)(35)^2 = 86\text{J}$; after contact the kinetic energy is $E_f = \frac{1}{2}(0.140)(45)^2 = 142\text{J}$. Thus the work done on the baseball by the bat is $\Delta E = 142 - 86 = 56\text{J}$. Since this energy transfer occurs over 7ms, the power is $P = \frac{\Delta E}{\Delta t} = \frac{56}{0.007} =$ **8000W.**