

Week 6: Momentum Additional Homework

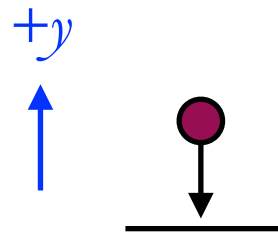
1. A 2.5kg Superball hits the floor with a speed of 5m/s. The floor exerts an average normal force of 1000N on the ball for 0.02s, and the superball bounces back up into the air. What is the superball's speed immediately after the collision?

	y
\vec{p}_i	$(2.5)(-5)$
\vec{J}	$(1000)(0.02)$
\vec{p}_f	$(2.5)v$

$$\vec{p} = m\vec{v}$$

$$\vec{J} = \vec{F}_{avg}\Delta t$$

$$\vec{p} = m\vec{v}$$



Remember that for momentum, sign matters!

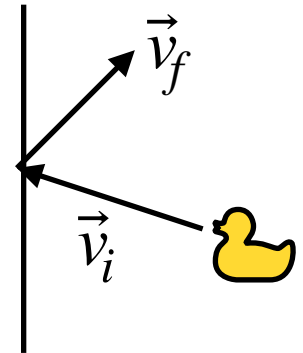
$$\begin{aligned} \vec{p}_i + \vec{J} &= \vec{p}_f \\ (2.5)(-5) + (1000)(0.02) &= (2.5)v \\ -12.5 + 20 &= 2.5v \\ v &= \frac{7.5}{2.5} = \mathbf{3m/s} \end{aligned}$$

2. A 0.4kg rubber duck hits a wall which exerts an average normal force of 250N on the duck over 8ms. If the duck's initial velocity is $(-3, +1)\text{m/s}$, what is the duck's final

a) velocity and

b) speed?

c) Did the duck slow down or speed up during hte collision?



	x	y
\vec{p}_i	$(0.4)(-3)$ $= -1.2\text{Ns}$	$(0.4)(1)$ $= 0.4\text{Ns}$
\vec{J}	$+250(0.008)$ $= 2\text{Ns}$	0
\vec{p}_f	$0.4v_{fx}$	$0.4v_{fy}$

The x column gives us

$$-1.2 + 2 = 0.4v_{fx} \implies v_{fx} = \frac{0.8}{0.4} = +2\text{m/s}$$

The y column gives us

$$0.4 + 0 = 0.4v_{fy} \implies v_{fy} = +1\text{m/s}$$

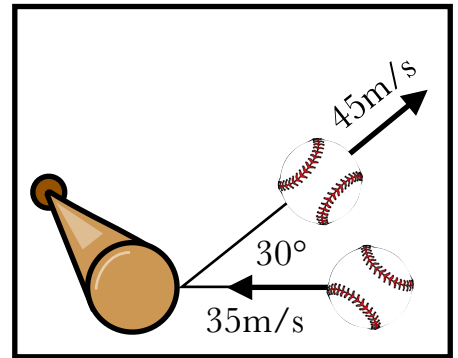
which is the same as the initial y -component of the velocity.

The overall velocity is thus $\vec{v}_f = (+2, +1)\text{m/s}$.

and the speed is $v_f = \sqrt{(2)^2 + (1)^2} = \sqrt{5} = 2.2\text{m/s}$.

The initial speed is $\sqrt{(3)^2 + (1)^2} = \sqrt{10} = 3.16\text{m/s}$, so the duck **slowed down** during the collision.

3. 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 magnitude of the average force $|F_{avg}|$ on the ball?



	x	y
\vec{p}_i	$(0.140)(-35)$	0
\vec{J}	$F_x(7 \times 10^{-3})$	$F_y(7 \times 10^{-3})$
\vec{p}_f	$0.140(45 \cos 30^\circ)$	$0.140(45 \sin 30^\circ)$

Write the unknown force as $\vec{F} = (F_x, F_y)$, and then
 $|\vec{F}| = \sqrt{F_x^2 + F_y^2}$

The x column: $(0.140)(-35) + F_x(7 \times 10^{-3}) = 0.140(45 \cos 30^\circ)$
 $-4.9 + 0.007F_x = 5.46$
 $0.007F_x = 10.36$
 $F_x = \frac{10.36}{0.007} = 1480\text{N}$

The y column: $0 + 0.007F_y = 0.140(45 \sin 30^\circ)$
 $0.007F_y = 3.15$
 $F_y = \frac{3.15}{0.007} = 450\text{N}$

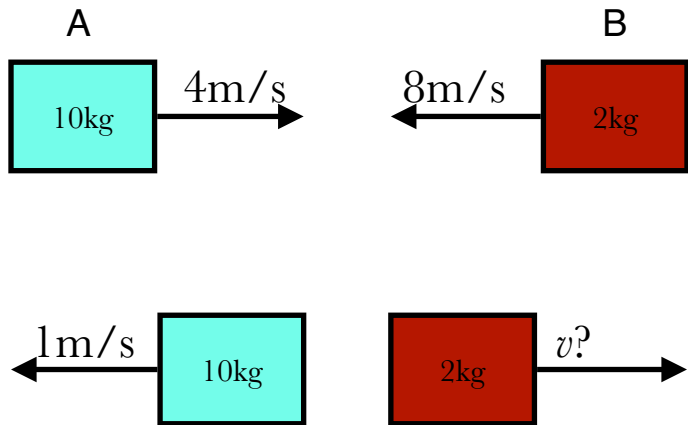
The magnitude:

$$|F_{avg}| = \sqrt{F_x^2 + F_y^2} = \sqrt{(1480)^2 + (450)^2} = 1547\text{ N}$$

4. A 10kg block and a 2kg block collide with the velocities shown.

a) What is the total momentum of the two blocks before the collision?

b) What is the velocity of the 2kg block after the collision?



\vec{p}_{Ai}	(10)(4)
\vec{p}_{Bi}	(2)(-8)
\vec{p}_{Af}	(10)(-1)
\vec{p}_{Bf}	(2) v

a) The total momentum before the collision, assuming to the right is the positive direction, is $(10\text{kg})(+4\text{m/s}) + (2\text{kg})(-8\text{m/s}) = 40 - 16 = \mathbf{24\text{Ns}}$.

b) The total momentum after the collision must be the same, due to conservation of momentum:

$$10(-1) + 2v = 24 \implies 2v = 34 \implies v = \mathbf{17\text{m/s}}$$