Worksheet: Conservation of Momentum **Name** *KEY*

1. A 1,250 kg car is stopped at a traffic light. A 3,550 kg truck moving at 8.33 m/s hits the car from behind. If bumpers lock, how fast will the two vehicles move?

$$1{,}250 \text{ kg} + 3{,}550 \text{ kg} = 4{,}800 \text{ kg combined}$$

$$\overbrace{(1{,}250 \text{ kg})(0 \tfrac{m}{s})}^{car} + \overbrace{(3{,}550 \text{ kg})(8.33 \tfrac{m}{s})}^{truck} = \overbrace{(4{,}800 \text{ kg})(v)}^{combined}$$

$$v = \boxed{6.16 \tfrac{m}{s}}$$

2. The muzzle velocity of a 50.0 g shell leaving a 3.00 kg rifle is 400. m/s. What is the recoil velocity of the rifle?

$$\overbrace{0 \tfrac{kg \cdot m}{s}}^{\text{momentum of shell and gun}} = \overbrace{(0.0500 \text{ kg})(400. \tfrac{m}{s})}^{shell} + \overbrace{(3.00 \text{ kg})(v)}^{gun}$$

$$v = \boxed{-6.67 \tfrac{m}{s}}$$

3. Imagine that you are hovering next to a space shuttle and your buddy of equal mass who is moving a 4 km/h with respect to the ship bumps into you. If he holds onto you, how fast do you both move with respect to the ship?

$$\overbrace{(M)(0 \tfrac{km}{h})}^{you} + \overbrace{(M)(4 \tfrac{km}{h})}^{\text{your buddy}} = \overbrace{(2M)(v)}^{combined}$$

$$4M \tfrac{km}{h} = 2M \cdot v$$

$$v = \frac{4 \cancel{M}}{2 \cancel{M}} \tfrac{km}{h} = \boxed{2 \tfrac{km}{h}}$$

4. Joe and his brother Bo have a combined mass of 200.0 kg and are zooming along in a 100.0 kg amusement park bumper car at 10.0 m/s. They bump into Melinda's car, which is sitting still. Melinda has a mass of 25.0 kg. After the collision, the twins continue ahead with a speed of 4.12 m/s. How fast is Melinda's car bumped across the floor?

Joe & Bo's car: 200.0 kg + 100.0 kg = 300.0 kg; Melinda's car: 25.0 kg + 100.0 kg = 125.0 kg

$$\overbrace{(300.0 \text{ kg})(10.0 \tfrac{m}{s})}^{\text{Joe \& Bo's car before}} + \overbrace{(125.0 \text{ kg})(0 \tfrac{m}{s})}^{\text{Melinda's car before}} = \overbrace{(300.0 \text{ kg})(4.12 \tfrac{m}{s})}^{\text{Joe \& Bo's car after}} + \overbrace{(125.0 \text{ kg})(v)}^{\text{Melinda's car after}}$$

$$v = \boxed{14.1 \tfrac{m}{s}}$$

5. If an 800. kg sports car slows to 13.0 m/s to check out an accident scene and the 1200. kg pick-up truck behind him continues traveling at 25.0 m/s, with what velocity will the two move if they lock bumpers after a rear-end collision?

$$800 \text{ kg} + 1{,}200 \text{ kg} = 2{,}000 \text{ kg combined}$$

$$\overbrace{(800 \text{ kg})(13.0 \tfrac{m}{s})}^{car} + \overbrace{(1{,}200 \text{ kg})(25.0 \tfrac{m}{s})}^{truck} = \overbrace{(2{,}000 \text{ kg})(v)}^{combined}$$

$$v = \boxed{20.2 \tfrac{m}{s}}$$

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6. Jamal is at Six Flags playing at the arcade. At one booth he throws a 0.50 kg ball forward with a velocity of 21.0 m/s in order to hit a 0.20 kg bottle sitting on a shelf, and when he makes contact the bottle goes flying forward at 30.0 m/s
   a. What is the velocity of the ball after it hits the bottle?
   b. If the bottle were more massive (but flew forward with the same final velocity), how would this affect the final velocity of the ball?

$$\overbrace{(0.50\ kg)(21.0\ \tfrac{m}{s})}^{ball} + \overbrace{(0.20\ kg)(0\ \tfrac{m}{s})}^{bottle} = \overbrace{(0.50\ kg)(v)}^{ball} + \overbrace{(0.20\ kg)(30.0\ \tfrac{m}{s})}^{bottle}$$

$$v = \boxed{9.0\ \tfrac{m}{s}}$$

Because the momentum of the system (ball + bottle) must remain constant, if the mass of the bottle is increased, the final momentum of the bottle is also increased; thus, the final momentum of the ball must decrease. The velocity of the ball will decrease.

7. Valentina, the Russian Cosmonaut, goes outside her ship for a space walk, but when she is floating motionless, 15 m from the ship, her tether catches on a sharp piece of metal and is severed. Valentina tosses her 2.0 kg camera away from the spaceship with a speed of 12 m/s.
   a. How fast will Valentina, whose mass is now 68 kg, travel toward the spaceship?
   b. Assuming the spaceship remains at rest with respect to Valentina, how long will it take her to reach the ship?

$$\overbrace{0\ \tfrac{kg\cdot m}{s}}^{\text{momentum of Val. and camera}} = \overbrace{(68\ kg)(v)}^{Valentina} + \overbrace{(2.0\ kg)(-12\ \tfrac{m}{s})}^{camera}$$

$$v = \boxed{0.35\ \tfrac{m}{s}}$$

$$v = \frac{d}{t} \qquad t = \frac{d}{v}$$

$$t = \frac{15\ m}{0.35\ \tfrac{m}{s}} = \boxed{43\ s}$$

8. A railroad diesel engine weighs 4 times as much as a flatcar. If the engine coasts at 5 km/h into a flatcar that is initially at rest, how fast do the two coast after they couple together?

$$\overbrace{(M)(0\ \tfrac{m}{s})}^{flatcar} + \overbrace{(4M)(5\ \tfrac{m}{s})}^{engine} = \overbrace{(4M+M)(v)}^{combined}$$

$$20M\ \tfrac{m}{s} = 5M \cdot v$$

$$v = \frac{20\cancel{M}}{5\cancel{M}}\ \tfrac{m}{s} = \boxed{4\ \tfrac{m}{s}}$$