

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?

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

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

$$v = \boxed{6.16 \frac{\text{m}}{\text{s}}}$$

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?

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

$$v = \boxed{-6.67 \frac{\text{m}}{\text{s}}}$$

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?

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

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

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

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?

$$\text{Joe \& Bo's car: } 200.0 \text{ kg} + 100.0 \text{ kg} = 300.0 \text{ kg}; \text{ Melinda's car: } 25.0 \text{ kg} + 100.0 \text{ kg} = 125.0 \text{ kg}$$

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

$$v = \boxed{14.1 \frac{\text{m}}{\text{s}}}$$

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?

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

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

$$v = \boxed{20.2 \frac{\text{m}}{\text{s}}}$$

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
- What is the velocity of the ball after it hits the bottle?
  - If the bottle were more massive (but flew forward with the same final velocity), how would this affect the final velocity of the ball?

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

$$v = \boxed{9.0 \frac{\text{m}}{\text{s}}}$$

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.
- How fast will Valentina, whose mass is now 68 kg, travel toward the spaceship?
  - Assuming the spaceship remains at rest with respect to Valentina, how long will it take her to reach the ship?

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

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

$$v = \boxed{0.35 \frac{\text{m}}{\text{s}}} \quad t = \frac{15 \text{ m}}{0.35 \frac{\text{m}}{\text{s}}} = \boxed{43 \text{ s}}$$

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?

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

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

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