10. (a) $\boxed{\text{No}}$, because velocity is also a factor in calculating momentum.

(b) Running back: $p = mv = (75\text{ kg})(8.5\text{ m/s}) = 638\text{ kg·m/s}$.
Lineman: $p = (120\text{ kg})(5.0\text{ m/s}) = 600\text{ kg·m/s}$.

So $\boxed{\text{the running back}}$ has more momentum, and the difference is

$\Delta p = 638\text{ kg·m/s} – 600\text{ kg·m/s} = \boxed{38\text{ kg·m/s more}}$.

15. (a) 36 km/h = 10 m/s. $p = mv = (1.29\text{ kg/m}^3)(1.0\text{ m}^3)(10\text{ m/s}) = \boxed{13\text{ kg·m/s}}$.

(b) 74 mi/h = 33.1 m/s. $p = (1.29\text{ kg/m}^3)(1.0\text{ m}^3)(33.1\text{ m/s}) = \boxed{43\text{ kg·m/s}}$.

$\boxed{20}$. $v_o = 3.0\text{ km/h} = 0.833\text{ m/s}$. $F_{avg} = \dfrac{\Delta p}{\Delta t} = \dfrac{mv - mv_o}{\Delta t} = \dfrac{(5.0 \times 10^3\text{ kg})(0 - 0.833\text{ m/s})}{0.64\text{ s}} = -\boxed{6.5 \times 10^3\text{ N}}$.

24. (a) The final velocity is equal in magnitude but opposite in direction to the initial velocity.

$\Delta p = m\Delta v = m(v - v_o) = m(-v_o - v_o) = -2mv_o = -2(120\text{ lb}) \times \dfrac{1\text{ kg}}{2.2\text{ lb}} \times (4.50\text{ m/s})$

$= –491\text{ kg·m/s} = \boxed{491\text{ kg·m/s downward}}$.

(b) $\boxed{\text{Yes}}$, there would be a difference.

$v^2 = v_o^2 - 2gy = (4.50\text{ m/s})^2 - 2(9.80\text{ m/s}^2)(-0.300\text{ m}) = 26.13\text{ m}^2/\text{s}^2$, ☞ $v = -5.11\text{ m/s}$.

So $\Delta p = (120\text{ lb}) \times \dfrac{1\text{ kg}}{2.2\text{ lb}} \times (-5.11\text{ m/s} - 4.50\text{ m/s}) = -524\text{ kg·m/s} = \boxed{524\text{ kg·m/s downward}}$.

25. (a) From either kinematics (Chapter 2) or the conservation of energy (Chapter 5), the velocity of the ball right before hitting the floor is $v_o = -\sqrt{2gy} = -\sqrt{2(9.80\text{ m/s}^2)(2.00\text{ m})} = -6.261\text{ m/s}$.
The velocity of the ball right after the impact is $v_o = \sqrt{2(9.8m/s)(1.10m)} = 4.643\text{ m/s}$.

$\Delta p = m\Delta v = m(v - v_o) = (0.200\text{ kg})[4.643\text{ m/s} – (–6.261\text{ m/s})] = 2.181\text{ kg m/s}$.

(b) $F_{avg} = \dfrac{\Delta p}{\Delta t} = \dfrac{mv - mv_o}{\Delta t} = \dfrac{2.181kgm/s}{0.0950s} = 22.9\text{ N}$.

The floor also needs to support the weight of the ball during impact.

$w = mg = (0.200\text{ kg})(9.80\text{ m/s}^2) = 1.96\text{ N}$. So the total force is $22.0\text{ N} + 1.96\text{ N} = \boxed{24.0\text{ N upward}}$.

38. (a) Impulse $= F_{avg}\,\Delta t = (100.0\text{ N})(0.200\text{ s}) = \boxed{20.0\text{ N·s}}$.

(b) $\vec{\mathbf{p}}_o = [(100\text{ kg})(0.750\text{ m/s})]\,\hat{\mathbf{x}} = (75.0\text{ kg·m/s})\,\hat{\mathbf{x}}$.

The impulse of 20.0 N·s = 20.0 kg·m/s is perpendicular to the x direction so it is in the y direction.

$\vec{\mathbf{F}}_{avg}\,\Delta t = \Delta\vec{\mathbf{p}} = \vec{\mathbf{p}} - \vec{\mathbf{p}}_o$, ☞ $\vec{\mathbf{p}} = \vec{\mathbf{p}}_o + \vec{\mathbf{F}}_{avg}\,\Delta t = (75.0\text{ kg·m/s})\,\hat{\mathbf{x}} + (20.0\text{ kg·m/s})\,\hat{\mathbf{y}}$.

$\theta = \tan^{-1}\left(\dfrac{20.0}{75.0}\right) = \boxed{14.9°}$.

(c) $p = \sqrt{(75.0\text{ kg·m/s})^2 + (20.0\text{ kg·m/s})^2} = 77.62\text{ kg·m/s}$. So $v = \dfrac{p}{m} = \dfrac{77.62\text{ kg·m/s}}{100\text{ kg}} = \boxed{0.776\text{ m/s}}$.

41. $F_{avg}\,\Delta t = mv - mv_o = -mv_o$, ☞ $F_{avg} = -\dfrac{mv_o}{\Delta t}$. So the magnitude is $\dfrac{mv_o}{\Delta t}$.

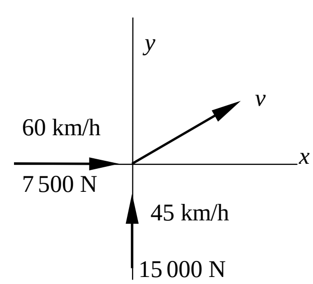
$F_{avg1} = \dfrac{(0.16\text{ kg})(25\text{ m/s})}{3.5 \times 10^{-3}\text{ s}} = \boxed{1.1 \times 10^3\text{ N}}$; $F_{avg2} = \dfrac{(0.16\text{ kg})(25\text{ m/s})}{8.5 \times 10^{-3}\text{ s}} = \boxed{4.7 \times 10^2\text{ N}}$.

45. (a) Apply momentum conservation $\vec{\mathbf{P}}_o = \vec{\mathbf{P}}$.

in x: $\dfrac{7500\text{ N}}{g}(60\text{ km/h}) + \dfrac{15\,000\text{ N}}{g}(0) = \dfrac{7500\text{ N}}{g}v_x + \dfrac{15\,000\text{ N}}{g}v_x$,

so $v_x = 20\text{ km/h}$.

in y: $\dfrac{7500\text{ N}}{g}(0) + \dfrac{15\,000\text{ N}}{g}(45\text{ km/h}) = \dfrac{7500\text{ N}}{g}v_y + \dfrac{15\,000\text{ N}}{g}v_y$,



so $v_y = 30$ km/h.

$v = \sqrt{(20\text{ km/h})^2 + (30\text{ km/h})^2} = \boxed{36\text{ km/h}}$, $\theta = \tan^{-1}\left(\dfrac{30}{20}\right) = \boxed{56° \text{ north of east}}$.

(b) The percentage of kinetic energy lost is

$$\frac{|\Delta K|}{K_o} = \frac{K_o - K}{K_o} = 1 - \frac{K}{K_o} \propto 1 - \frac{\frac{1}{2}(7500 + 15\,000)(36)^2}{\frac{1}{2}(7500)(60)^2 + \frac{1}{2}(15\,000)(45)^2} = 1 - 0.51 = 0.49 = \boxed{49\% \text{ lost}}.$$

Note the proportional sign $\propto$ in the calculation.

46. 40 km/h = 11.1 m/s, 2400 lb = 10 680 N. The force on the infant is opposite to velocity.

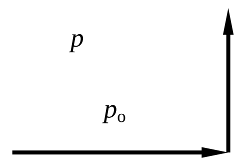
$F_{avg}\Delta t = mv - mv_o$, ☞ $\Delta t = \dfrac{mv - mv_o}{F_{avg}} = \dfrac{(55\text{ kg})(0 - 11.1\text{ m/s})}{-10\,680\text{ N}} = \boxed{0.057\text{ s}}$.

47. $\vec{\mathbf{p}}_o = (0.200\text{ kg})(35.0\text{ m/s})\,\hat{\mathbf{x}} = (7.00\text{ kg·m/s})\,\hat{\mathbf{x}}$, $\vec{\mathbf{p}} = (0.200\text{ kg})(20.0\text{ m/s})\,\hat{\mathbf{y}} = (4.00\text{ kg·m/s})\,\hat{\mathbf{y}}$,

Impulse $= \vec{\mathbf{F}}_{avg}\Delta t = \Delta\vec{\mathbf{p}} = \vec{\mathbf{p}} - \vec{\mathbf{p}}_o = (-7.00\text{ kg·m/s})\,\hat{\mathbf{x}} + (4.00\text{ kg·m/s})\,\hat{\mathbf{y}}$.

So the magnitude of impulse is $\sqrt{(-7.00\text{ kg·m/s})^2 + (4.00\text{ kg·m/s})^2} = \boxed{8.06\text{ kg·m/s}}$,

and the direction is $\theta = \tan^{-1}\left(\dfrac{4.00}{7.00}\right) = \boxed{29.7° \text{ above the } -x \text{ axis}}$.



57. $m_1 = 0.150$ kg, $m_2 = 70.0$ kg, $v_{1o} = 0$, $v_{2o} = 0$, $v_1 = 2.00$ m/s, $v_2 = ?$

$\vec{\mathbf{P}}_o = \vec{\mathbf{P}}$, ☞ $m_1 v_{1o} + m_2 v_{2o} = m_1 v_1 + m_2 v_2$.

$$v_2 = \frac{m_1 v_{1o} + m_2 v_{2o} - m_1 v_1}{m_2} = \frac{0 + 0 - (0.150\text{ kg})(2.00\text{ m/s})}{65.0\text{ kg}} = -4.615 \times 10^{-3}\text{ m/s}.$$

Therefore it takes $\dfrac{5.00\text{ m}}{4.615 \times 10^{-3}\text{ m/s}} = \boxed{1.08 \times 10^3\text{ s} = 18.1\text{ min}}$.

67. (a) The stunt man has zero horizontal velocity before he jumps onto the sled.

Apply momentum conservation $\vec{\mathbf{P}}_o = \vec{\mathbf{P}}$ in the horizontal direction.

$(75\text{ kg})(0) + (50\text{ kg})(10\text{ m/s}) = (75\text{ kg} + 50\text{ kg})\,v = (125\text{ kg})\,v$, ☞ $v = \boxed{4.0\text{ m/s}}$.

(b) The stunt man's momentum is still conserved by himself, so he continues to move with $\boxed{4.0\text{ m/s}}$.

71. (a) Apply momentum conservation $\vec{\mathbf{P}}_o = \vec{\mathbf{P}}$

in x-axis: $(0.010\text{ kg})(2000\text{ m/s}) + 0 = (0.010\text{ kg})(1000\text{ m/s})\cos 10° + (100\text{ kg})\,v_{2x}$,

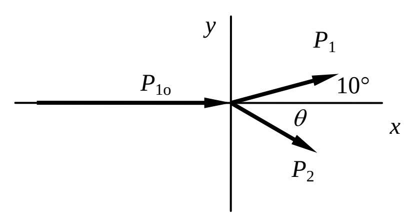
so $v_{2x} = 0.1015$ m/s;

in y-axis: $0 + 0 = (0.010\text{ kg})(1000\text{ m/s})\sin 10° + (100\text{ kg})\,v_{2y}$,

so $v_{2y} = -0.01736$ m/s.

$\theta_2 = \tan^{-1}\left(\dfrac{-0.01736}{0.1015}\right) = \boxed{9.7°}$ below the $+x$-axis.

(b) $v_2 = \sqrt{(0.1015\text{ m/s})^2 + (-0.0174\text{ m/s})^2} = \boxed{0.10\text{ m/s}}$.



84. From Equations 6.14 and 6.15 (1 = Jill's car and 2 = Rob's car):

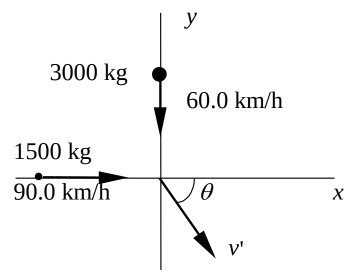
$$v_J = \left(\frac{m_J - m_R}{m_J + m_R}\right) v_{J_o} + \left(\frac{2m_R}{m_J + m_R}\right) v_{R_o} = \frac{325\text{ kg} - 290\text{ kg}}{325\text{ kg} + 290\text{ kg}} \times (-3.50\text{ m/s}) + \frac{2(290\text{ kg})}{325\text{ kg} + 290\text{ kg}} \times (2.00\text{ m/s})$$

$= +1.69\text{ m/s} = \boxed{1.69\text{ m/s, right}}$.

$$v_R = \left(\frac{2m_J}{m_J + m_R}\right) v_{J_o} - \left(\frac{m_J - m_R}{m_J + m_R}\right) v_{R_o} = \frac{2(325\text{ kg})}{325\text{ kg} + 290\text{ kg}} \times (-3.50\text{ m/s}) - \frac{325\text{ kg} - 290\text{ kg}}{325\text{ kg} + 290\text{ kg}} \times (2.00\text{ m/s})$$

$= -3.81\text{ m/s} = \boxed{3.81\text{ m/s, left}}$.

91. (a) Right after the collision, the car and minivan will move toward a general direction $\boxed{\text{(1) south of east}}$, according to momentum conservation. The initial momentum of the minivan is to the south, and the initial momentum of the car is to the east, so the two-vehicle system has a total momentum to the southeast after the collision.



(b) 90.0 km/h = 25.0 m/s, 60.0 km/h = 16.67 m/s.

Using the result of Exercise 6.90, we have $v'_x = \dfrac{m\,v}{m+M}$ and $v'_y = \dfrac{M\,V}{m+M}$.

$$v' = \frac{\sqrt{m^2\,v^2 + M^2\,V^2}}{m+M} = \frac{\sqrt{(1500\text{ kg})^2\,(25.0\text{ m/s})^2 + (3000\text{ kg})^2\,(16.67\text{ m/s})^2}}{1500\text{ kg} + 3000\text{ kg}} = \boxed{13.9\text{ m/s}}.$$

$$\theta = \tan^{-1}\left[\frac{(3000\text{ kg})(16.67\text{ m/s})}{(1500\text{ kg})(25.0\text{ m/s}}\right] = \boxed{53.1^\circ\text{ south of east}}.$$

95. (a) $v_1 = \dfrac{m_1 - m_2}{m_1 + m_2}\,v_{1o} = \dfrac{m - 12m}{m + 12m}\,v_{1o} = \frac{11}{13}\,v_{1o}$.

So the fraction of kinetic energy lost is $\dfrac{|\Delta K|}{K_o} = \dfrac{K_o - K}{K_o} = 1 - \dfrac{K}{K_o} = 1 - \dfrac{\frac{1}{2}m\,(\frac{11}{13})^2\,v_{1o}^2}{\frac{1}{2}m\,v_{1o}^2} = 0.28 = \boxed{28\%}$.

(b) $v_1 = \frac{11}{13}\,(1.5\times10^7\text{ m/s}) = \boxed{1.3\times10^7\text{ m/s}}$.

96. First consider the collision between car 1 and 2.

$$v_1 = \frac{m_1 - m_2}{m_1 + m_2}\,v_{1o} = \frac{2000\text{ kg} - 1500\text{ kg}}{2000\text{ kg} + 1500\text{ kg}} \times (15.0\text{ m/s}) = \boxed{2.14\text{ m/s}}.$$

$$v_2 = \frac{2m_1}{m_1 + m_2}\,v_{1o} = \frac{2(2000\text{ kg})}{2000\text{ kg} + 1500\text{ kg}} \times (15.0\text{ m/s}) = \boxed{17.1\text{ m/s}}.$$

Now consider the collision between car 2 and 3.

The 17.1 m/s becomes the initial velocity in this collision. $v_2 = v_3 = v$.

$(1500\text{ kg})(17.1\text{ m/s}) + (2500\text{ kg})(0) = (1500\text{ kg} + 2500\text{ kg})\,v$, ☞ $v = \boxed{6.41\text{ m/s}}$.

111. The CM of the board is at its center, or 1.00 m to right end of the pole. Choose the right end of the board as $x = 0$. The CM of the system is at $X_{CM} = 0.95$ m (where the cylinder is).

$$-0.95\text{ m} = X_{CM} = \frac{\Sigma\,m_i\,x_i}{M} = \frac{(0.200\text{ kg})(-2.00\text{ m}) + (2.00\text{ kg})(-1.00\text{ m}) + (0.400\text{ kg})\,x_2}{0.200\text{ kg} + 2.00\text{ kg} + 0.400\text{ kg}},$$

so $x_2 = \boxed{0.175\text{ m}}$ from the right end of the board.