Q5

(a) $$\vec{V}_{com} = \frac{m_1\vec{v}_1 + m_2\vec{v}_2}{m_1 + m_2}$$ for two particles

Since we need the center of mass to be stationary ($\vec{V}_{com} = 0$) and $m_2 = m_1$

$$\Rightarrow \vec{v}_1 = -\vec{v}_2 .$$

pairs a, c
b, c
c, d

(b) $$x_{com} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$$

$$0 = \frac{m x_1 + m x_2}{m_1 + m_2}$$

$$0 = x_1 + x_2$$

OR $x_1 = -x_2$

Similarly $y_1 = -y_2$

pairs b, c

(c) pairs a, d (not stationary)
b, c

Q6 (a) stationary $\Rightarrow a_{com} = 0$ and $V_{com} = 0$

$$F_{net} = M a_{com} = 0$$

$\Rightarrow \vec{F}_{net} = 0 \Rightarrow F_3 = 3\,N$ to right.

(b) constant velocity $\Rightarrow \vec{a}_{com} = 0$

$\Rightarrow F_3 = 3\,N$ to right

(c) $F_3 > 3\,N$ to right.

4. We will refer to the arrangement as a "table." We locate the coordinate origin at the center of the tabletop and note that the center of mass of each "leg" is a distance $L/2$ below the top. With $+x$ rightward and $+y$ upward, then the center of mass of the right leg is at $(x, y) = (+L/2, -L/2)$ and the center of mass of the left leg is at $(x, y) = (-L/2, -L/2)$. Thus, the x coordinate of the (whole table) center of mass is

$$x_{\text{com}} = \frac{M\,(+L/2) + M\,(-L/2)}{M + M + 3M} = 0$$

as expected. And the y coordinate of the (whole table) center of mass is

$$y_{\text{com}} = \frac{M\,(-L/2) + M\,(-L/2)}{M + M + 3M} = -\frac{L}{5}$$

so that the whole table center of mass is a small distance $(0.2L)$ directly below the middle of the tabletop.

11. Let m_c be the mass of the Chrysler and v_c be its velocity. Let m_f be the mass of the Ford and v_f be its velocity. Then the velocity of the center of mass is

$$v_{\text{com}} = \frac{m_c v_c + m_f v_f}{m_c + m_f} = \frac{(2400\,\text{kg})(80\,\text{km/h}) + (1600\,\text{kg})(60\,\text{km/h})}{2400\,\text{kg} + 1600\,\text{kg}} = 72\,\text{km/h}\,.$$

We note that the two velocities are in the same direction, so the two terms in the numerator have the same sign.

16. The implication in the problem regarding $\vec{v}_0$ is that the olive and the nut start at rest. Although we could proceed by analyzing the forces on each object, we prefer to approach this using Eq. 9-14. The total force on the nut-olive system is $\vec{F}_{\mathbf{o}} + \vec{F}_{\mathbf{n}} = -\hat{\text{i}} + \hat{\text{j}}$ with the unit newton understood. Thus, Eq. 9-14 becomes

$$-\hat{\text{i}} + \hat{\text{j}} = M\vec{a}_{\text{com}}$$

where $M = 2.0$ kg. Thus, $\vec{a}_{\text{com}} = -\frac{1}{2}\hat{\text{i}} + \frac{1}{2}\hat{\text{j}}$ in SI units. Each component is constant, so we apply the equations discussed in Chapters 2 and 4.

$$\Delta\vec{r}_{\text{com}} = \frac{1}{2}\vec{a}_{\text{com}}t^2 = -4.0\,\hat{\text{i}} + 4.0\,\hat{\text{j}}$$

(in meters) when $t = 4.0$ s. It is perhaps instructive to work through this problem the *long way* (separate analysis for the olive and the nut and then application of Eq. 9-5) since it helps to point out the computational advantage of Eq. 9-14.

22. The magnitude of the ball's momentum change is

$$\Delta p = |mv_i - mv_f| = (0.70\,\mathrm{kg})\,|5.0\,\mathrm{m/s} - (-2.0\,\mathrm{m/s})| = 4.9\ \mathrm{kg\cdot m/s}\ .$$

39. Our notation (and, implicitly, our choice of coordinate system) is as follows: the mass of one piece is $m_1 = m$; ; its velocity is $\vec{v}_1 = -30\,\hat{\text{i}}$ in SI units (m/s); the mass of the second piece is $m_2 = m$; ; its velocity is $\vec{v}_2 = -30\,\hat{\text{j}}$ in SI units; and, the mass of the third piece is $m_3 = 3m$. Conservation of linear momentum requires

$$\begin{aligned} m\vec{v}_0 &= m_1\vec{v}_1 + m_2\vec{v}_2 + m_3\vec{v}_3 \\ 0 &= m\left(-30\,\hat{\text{i}}\right) + m\left(-30\,\hat{\text{j}}\right) + 3m\vec{v}_3 \end{aligned}$$

which leads to

$$\vec{v}_3 = 10\,\hat{\text{i}} + 10\,\hat{\text{j}}$$

in SI units. Its magnitude is $v_3 = 10\sqrt{2} \approx 14$ m/s and its angle is 45° counterclockwise from $+x$ (in this system where we have m_1 flying off in the $-x$ direction and m_2 flying off in the $-y$ direction).