42. Assume that the road is horizontal and the velocities are collinear. If "icy" means no friction, the total momentum before any collisions, $m_1v_1 + m_2v_2 + m_3v_3$, equals the momentum of the wreckage afterwards, $(m_1 + m_2 + m_3)v$. Therefore, the speed of the wreckage is

$$\frac{(1200\text{ kg})(50\text{ km/h}) + (4400\text{ kg})(35\text{ km/h}) + (1500\text{ kg})(65\text{ km/h})}{1200\text{ kg} + 4400\text{ kg} + 1500\text{ kg}} = 43.9\text{ km/h}$$

48. In a coordinate system floating with the astronaut and her/his equipment before they are separated, the conservation of momentum requires that $m_1\vec{v}_1 + m_2\vec{v}_2 + m_3\vec{v}_3 = 0$ (1, 2, 3 representing astronaut, tank, and camera). Since the masses and two velocities are given,

$$v_{3x} = -\frac{(60\text{ kg})(0.85\text{ m/s})\cos 200° + (14\text{ kg})(1.6\text{ m/s})}{5.8\text{ kg}} = 4.40\text{ m/s}$$

and $v_{3y} = -(60\text{ kg})(0.85\text{ m/s})\sin 200° = (5.8\text{ kg}) = 3.01\text{ m/s}$, or $v_3 = 5.33$ m/s at 34.3° CCW from the x axis.

50. If there are no external forces on the cart/sprinter system, with components along the direction of motion (positive in the direction of the sprinter), then the total momentum in that direction is conserved, or $P_{\text{tot}} = (m_s + m_c)v_{cm} = m_sv_s + m_cv_c = \text{constant}$. The velocity of the sprinter relative to the cart is $v_{\text{rel}} = v_s - v_c$, so $(m_s + m_c)v_{cm} = m_sv_s + m_c(v_s - v_{\text{rel}}) = (m_s + m_c)v_s - m_cv_{\text{rel}}$. v_{cm} is a constant -7.6 m/s, so $v_s = 0$ when $v_{\text{rel}} = -(m_s + m_c)v_{cm}/m_c = -(55 + 240) \times (-7.6\text{ m/s})/240 = 9.34$ m/s.

58. In order to conserve momentum, the piece that is not at rest must acquire a velocity equal to twice that of the original kernel, $m\vec{v}_i = (\frac{1}{2}m)\vec{v}_{1f}$. Therefore, the final energy is twice the initial energy, $K_f = \frac{1}{2}(\frac{1}{2}m)v_{1f}^2 = \frac{1}{2}(\frac{1}{2}m)(2v_i)^2 = mv_i^2 = 2K_i$. The energy released is $K_f - K_i = K_i = \frac{1}{2}(4\times10^{-4}\text{ kg})\times(0.082\text{ m/s})^2 = 1.34\times10^{-6}$ J.

68. Assume that momentum is conserved during this one-dimensional, vertical, totally inelastic collision between the mud and the Frisbee (i.e., suppose the Frisbee is merely resting on a branch, that there is no interference from leaves, etc.). Just before the collision, the initial velocity of the mud is $v_y = \sqrt{v_{0y}^2 - 2g(y - y_0)} = \sqrt{(17.7\text{ m/s})^2 - 2(9.8\text{ m/s}^2)(7.65\text{ m} - 1.23\text{ m})} = 13.7$ m/s (positive upward, see Equation 2.11). Just after the collision, the final velocity of the combination of Frisbee and mud is $\vec{V}_y = mv_y/(m + M) = (240 = 354)(13.7\text{ m/s}) = 9.28$ m/s (see Equation 9.11 or Example 9.10). **(a)** Therefore, the combination travels $h = V_y^2/2g = 4.40$ m higher, to a total height of $4.40\text{ m} + 7.65\text{ m} = 12.0$ m above the ground. **(b)** An object falling from this height, unimpeded by air resistance or other obstacles, would attain a speed of $\sqrt{2(9.8\text{ m/s}^2)(12.0\text{ m})} = 15.4$ m/s when it reached the ground.

78. **INTERPRET** We use conservation of momentum to find the speed of an astronaut after she throws her toolbox away, and use this speed and a given distance to determine whether she reaches safety within a set time.
DEVELOP The mass of the astronaut is $m_a = 80$ kg. The mass of the toolbox is $m_t = 10$ kg. The initial speed of both is zero, and the final speed of the toolbox is $v_{ta} = -8$ m/s *relative to the astronaut.* We can use conservation of momentum to find the speed of the astronaut: $0 = m_tv_t + m_av_a$. Once we have this speed, we calculate how long it will take to travel a distance $x = 200$ m, and hope that the answer is less than 4 minutes.
EVALUATE First we find the speed of the toolbox relative to the rest frame: $v_t = v_a + v_{ta}$. Next we plug this into the conservation of momentum equation: $0 = m_t(v_a + v_{ta}) + m_av_a$, and solve for the astronaut's speed:

$$0 = m_t(v_a + v_{ta}) + m_av_a \rightarrow v_a(m_t + m_a) = -m_tv_{ta} \rightarrow v_a = v_{ta}\left(-\frac{m_t}{m_t + m_a}\right) = 0.89\text{ m/s}$$

The time it takes is $t = \frac{x}{v_a} = \frac{200\text{ m}}{0.89\text{ m/s}} = 225\text{ s} = 3.75$ min.
ASSESS She makes it with 15 seconds to spare. Notice that the speed at which the toolbox moves away from the astronaut is not the speed of the toolbox!