44. A package is dropped from a helicopter traveling at 15 m/s horizontally at an altitude of 200m, but the parachute fails to open. (a)How long does it take for the package to hit ground? (b) How far does the package travel horizontally before hitting the ground? (c) What is the speed of the package before it lands?

10.44. (*a*) Because the package falls under the influence of gravity and therefore has constant acceleration, we can use kinematic equations like $\Delta y = v_{y,\mathrm{i}}\Delta t + \frac{1}{2}a_y \Delta t^2$. Since the initial velocity upon release is entirely horizontal, we can rearrange this to obtain $\Delta t = \sqrt{\frac{2\Delta y}{a_y}} = \sqrt{\frac{2(-200\ \mathrm{m})}{(-9.8\ \mathrm{m/s^2})}} = 6.4\ \mathrm{s}$. (*b*) Ignoring air resistance, the package will have a constant x component of it velocity, since there is nothing to accelerate it in the horizontal direction. Thus $\Delta x = v_{x,\mathrm{i}}\Delta t = (15\ \mathrm{m/s})(6.39\ \mathrm{s}) = 96\ \mathrm{m}$. (*c*) This could be solved using either kinematics or energy methods. We use the former. The final y component of the velocity is given by $v_{y,\mathrm{f}}^2 = v_{y,\mathrm{i}}^2 + 2a_y\Delta y \Rightarrow v_{y,\mathrm{f}} = -\sqrt{v_{y,\mathrm{i}}^2 + 2a_y\Delta y} = -\sqrt{(0) + 2(-9.8\ \mathrm{m/s})(-200\ \mathrm{m})} = -62.6\ \mathrm{m/s}$. The speed of the package as it lands is $v = \sqrt{v_{x,\mathrm{f}}^2 + v_{y,\mathrm{f}}^2} = \sqrt{(15\ \mathrm{m/s})^2 + (-62.6\ \mathrm{m/s})^2} = 64\ \mathrm{m/s}$.

46. A cannon launches two shells at the same speed, one at 55° above horizontal and one at 35° above horizontal. Which shell, if either, has the longer range? Which shell, if either, is in the air longer? Assume level ground and ignore air resistance. ••

10.46. Example 10.6 in the *Principles* text shows that the expression for the range in such a situation is $\Delta x = v_{x,\mathrm{i}}\left(\frac{2v_{y,\mathrm{i}}}{g}\right)$. For this specific case we can write this as $\Delta x = \frac{2v^2}{g}\sin(\theta)\cos(\theta)$ or $\Delta x = \frac{v^2}{g}\sin(2\theta)$. But $\sin(2(35°)) = \sin(2(55°))$, so the two shells have the same range. An expression for the time in the air can be found by considering the kinematic equation $v_{y,\mathrm{f}} = v_{y,\mathrm{i}} + a_y\Delta t$, and noting that the path of the shell is symmetric about its highest point (meaning that $v_{y,\mathrm{f}} = -v_{y,\mathrm{i}}$. Thus $\Delta t = \frac{-2v_{y,\mathrm{i}}}{a_y}$. So the shell with the greatest initial y component of its velocity will be in the air the longer. Clearly, the shell fired at $55°$ will be in the air longer.