Answer to Essential Question 4.8 No. The range equation applies only in the special case when a projectile's initial and final heights are the same. In this case, the final position is 2.00 m higher than the initial position.

Chapter Summary

Essential Idea - The Independence of x and y

This powerful concept enables us to split a two-dimensional problem into two one-dimensional problems, in a situation like projectile motion when the force applied to the projectile is constant. The motion in one direction is completely unaffected by the motion in the perpendicular direction, except that the two motions share the same time.

Relative Velocity

A relative velocity problem is a vector addition problem. The velocity of A to C is the vector sum of the velocity of A relative to B plus the velocity of B relative to C:

$$\vec{v}_{AC} = \vec{v}_{AB} + \vec{v}_{BC} \qquad \text{(Equation 4.1)}$$

Rules of Thumb for Projectile Motion (motion under the influence of gravity alone)

- The motion is symmetric, with the downward part of the motion being a mirror image of the upward part of the motion.
- The larger the initial vertical velocity, the higher the projectile goes.
- The higher a projectile goes, the longer the time of flight.
- Range is maximized when the launch angle is 45˚, as long as the projectile lands at the same height from which it was launched.

General Method for Solving a Two-Dimensional Motion Problem

The basic method is to split a two-dimensional motion problem into two one-dimensional subproblems, which we can call the *x* subproblem and the *y* subproblem.

1. Draw a diagram of the situation.
2. Draw a free-body diagram of the object showing all the forces acting on the object while it is in motion. A free-body diagram helps in determining the acceleration of the object.
3. Choose an origin.
4. Choose an *x*-*y* coordinate system, showing which way is positive for each direction.
5. Organize your data, keeping the information for the *x* subproblem separate from the information for the *y* subproblem.
6. As long as the acceleration is constant, apply the constant-acceleration equations. These equations are based on the equations from Chapter 2:

***x* equations**	***y* equations**
$v_x = v_{ix} + a_x t$ (Equation 4.2x)	$v_y = v_{iy} + a_y t$ (Equation 4.2y)
$x = x_i + v_{ix}t + \frac{1}{2}a_x t^2$ (Equation 4.3x)	$y = y_i + v_{iy}t + \frac{1}{2}a_y t^2$ (Equation 4.3y)
$v_x^2 = v_{ix}^2 + 2a_x\Delta x$ (Equation 4.4x)	$v_y^2 = v_{iy}^2 + 2a_y\Delta y$ (Equation 4.4y)