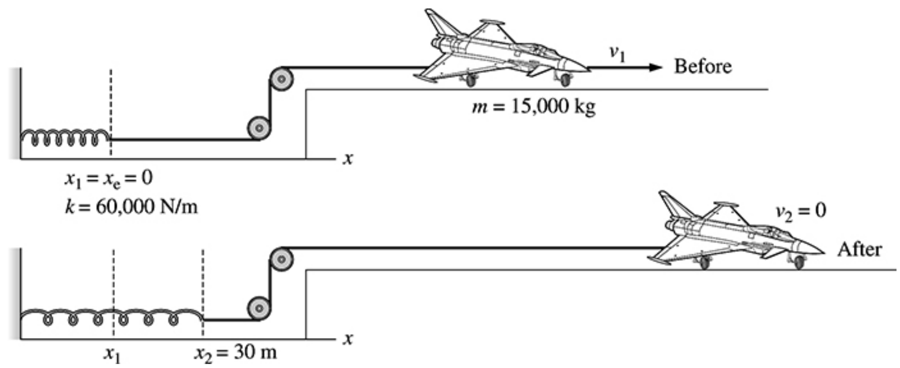
10.24. Model: Model the jet plane as a particle, and the spring as an ideal that obeys Hooke's law. We will also assume zero rolling friction during the stretching of the spring, so that mechanical energy is conserved.

Visualize:



The figure shows a before-and-after pictorial representation. The "before" situation occurs just as the jet plane lands on the aircraft carrier and the spring is in its equilibrium position. We put the origin of our coordinate system at the right free end of the spring. This gives $x_1 = x_e = 0$ m. Since the spring stretches 30 m to stop the plane, $x_2 - x_e = 30$ m.

Solve: The conservation of energy equation $K_2 + U_{s2} = K_1 + U_{s1}$ for the spring-jet plane system is

$$\frac{1}{2}mv_2^2 + \frac{1}{2}k(x_2 - x_e)^2 = \frac{1}{2}mv_1^2 + \frac{1}{2}k(x_1 - x_e)^2$$

Using $v_2 = 0$ m/s, $x_1 = x_e = 0$ m, and $x_2 - x_e = 30$ m yields

$$\frac{1}{2}k(x_2 - x_e)^2 = \frac{1}{2}mv_1^2 \Rightarrow v_1 = \sqrt{\frac{k}{m}}(x_2 - x_1) = \sqrt{\frac{60,000 \text{ N/m}}{15,000 \text{ kg}}}(30 \text{ m}) = 60 \text{ m/s}$$

Assess: A landing speed of 60 m/s or ≈120 mph is reasonable.