

17. We take the reference point for gravitational potential energy at the position of the marble when the spring is compressed.

- (a) The gravitational potential energy when the marble is at the top of its motion is $U_g = mgh$, where $h = 20$ m is the height of the highest point. Thus,

$$U_g = (5.0 \times 10^{-3} \text{ kg}) (9.8 \text{ m/s}^2) (20 \text{ m}) = 0.98 \text{ J} .$$

- (b) Since the kinetic energy is zero at the release point and at the highest point, then conservation of mechanical energy implies $\Delta U_g + \Delta U_s = 0$, where ΔU_s is the change in the spring's elastic potential energy. Therefore, $\Delta U_s = -\Delta U_g = -0.98 \text{ J}$.
- (c) We take the spring potential energy to be zero when the spring is relaxed. Then, our result in the previous part implies that its initial potential energy is $U_s = 0.98 \text{ J}$. This must be $\frac{1}{2}kx^2$, where k is the spring constant and x is the initial compression. Consequently,

$$k = \frac{2U_s}{x^2} = \frac{2(0.98 \text{ J})}{(0.080 \text{ m})^2} = 3.1 \times 10^2 \text{ N/m} = 3.1 \text{ N/cm} .$$