Momentum and Energy Practice Questions

1. A rock is thrown from a bridge with a speed of 12 m/s. The bridge is 50 m above a river. Assuming no energy is lost to thermal energy. What is the speed of the rock as it hits the water if it is thrown?

If the ball is thrown straight up, then $E_T = E_T'$. But $E_T = E_k + E_g$

and $E_T'=E_k$. Thus $m\left(\frac{v_i^2}{2}+g\Delta h\right)=\frac{1}{2}mv_f^2$ so that

$$v_f=\sqrt{v_i^2+2g\Delta h}=\sqrt{12^2+2(9.8)(50)}=33.5\frac{m}{s}$$

2. A cyclist is riding at a speed of 3.5 m/s at the top of a hill, then begins to coast down the hill. If the hill is 15 m high, how fast will they be going at the bottom of the hill? Assume that no energy is "lost" to air resistance or friction. The mass of the bike and rider together is 75 kg (although you don't need this for this question)

$$E_T=E_T' \qquad E_T= E_k+E_g= m\left(\frac{v_i^2}{2}+g\Delta h\right) \quad E_T'=\frac{mv_f^2}{2}$$

$$v_f=\sqrt{v_i^2+2g\Delta h}=\sqrt{3.5^2+2(9.8)(15)}=17.5\frac{m}{s}$$

3. Do question 2 again, but assume that a frictional force of 20 N acts on the bike while it travels a distance of 25 m along the hill.

   In this case the change in energy is equivalent to the work done on the cyclist. Since there is an external force acting on the system,

$$W_{ext} = F\Delta d\cos\theta = \Delta E = E_T' - E_T = m\left[\frac{v_f^2}{2}-\left(\frac{v_i^2}{2}+g\Delta h\right)\right] \rightarrow$$

$$\sqrt{2\left[\frac{F\Delta d\cos\theta}{m}+\left(\frac{v_i^2}{2}+g\Delta h\right)\right]}=v_f \rightarrow \sqrt{2\left[\frac{(20)(25)\cos 180}{75}+\left(\frac{12.25}{2}+(9.8)(15)\right)\right]}=17.1\frac{m}{s}$$

4. A 62 kg skydiver drops from an airplane that is moving horizontally at a speed of 75 m/s. Ten seconds later, the skydiver's speed is 85 m/s and she has fallen 500 m. How much energy has been "lost" to the air as thermal energy by this point?