94. (First problem in **Cluster 1**)

We take the bottom of the incline to be the $y = 0$ reference level. The incline angle is $\theta = 30°$. The distance along the incline d (measured from the bottom) is related to height y by the relation $y = d \sin\theta$.

(a) Using the conservation of energy, we have

$$K_0 + U_0 = K_{\text{top}} + U_{\text{top}} \implies \frac{1}{2}mv_0^2 + 0 = 0 + mgy$$

with $v_0 = 5.0$ m/s. This yields $y = 1.3$ m, from which we obtain $d = 2.6$ m.

(b) An analysis of forces in the manner of Chapter 6 reveals that the magnitude of the friction force is $f_k = \mu_k mg\cos\theta$. Now, we write Eq. 8-31 as

$$\begin{aligned} K_0 + U_0 &= K_{\text{top}} + U_{\text{top}} + f_k d \\ \frac{1}{2}mv_0^2 + 0 &= 0 + mgy + f_k d \\ \frac{1}{2}mv_0^2 &= mgd\sin\theta + \mu_k mgd\cos\theta \end{aligned}$$

which – upon cancelling the mass and rearranging – provides the result for d:

$$d = \frac{v_0^2}{2g\left(\mu_k\cos\theta + \sin\theta\right)} = 1.5 \text{ m} .$$

(c) The thermal energy generated by friction is $f_k d = \mu_k mgd\cos\theta = 26$ J.

(d) The slide back down, from the height $y = 1.5\sin 30°$ is also described by Eq. 8-31. With ΔE_{th} again equal to 26 J, we have

$$K_{\text{top}} + U_{\text{top}} = K_{\text{bot}} + U_{\text{bot}} + f_k d \implies 0 + mgy = \frac{1}{2}mv_{\text{bot}}^2 + 0 + 26$$

from which we find $v_{\text{bot}} = 2.1$ m/s.