a) Choose a coordinate system with \( \mathbf{j} \) pointing up and \( \mathbf{i} \) pointing to the right, in the direction of the student’s horizontal velocity component. Choose the origin \( 4.0 \text{ m} \) directly below the student’s starting position, so her initial position vector is \( (4.0 \text{ m}) \mathbf{j} \).

b) At the top of the slide the speed of the student is zero, so the kinetic energy is zero as well. Therefore the total mechanical energy is

\[
E = 0 \text{ J} + mgy = (80.0 \text{ kg})(9.81 \text{ m/s}^2)(4.0 \text{ m}) = 3.1 \times 10^3 \text{ J}.
\]

c) Use the CWE theorem with the initial position at the top of the incline and the final position at the bottom of the incline before the rough ground. During the slide down the frictionless incline, the normal force does no work, while the work from the weight is accounted for by the potential energy term. Thus

\[
0 \text{ J} = W_{\text{nonconservative}} = \Delta(KE + PE) = (KE + PE)_f - (KE + PE)_i = \left( \frac{mv^2}{2} + 0 \text{ J} \right) - \left( 0 \text{ J} + mgy \right)
\]

\[
\implies v = \sqrt{2gy} = \sqrt{2(9.81 \text{ m/s}^2)(4.0 \text{ m})} = 8.9 \text{ m/s}.
\]

d) Use the CWE theorem with the initial position at the bottom of the incline before the rough ground and the final position at rest some distance \( \ell \) along the rough ground. Along the horizontal section, the normal force has a magnitude equal to that of the weight. (This can be shown by applying Newton’s second law to the vertical direction along which there is zero acceleration). The force of kinetic friction is a constant force along the straight, horizontal path, so its work is

\[
W_{\text{nonconservative}} = \vec{f}_k \cdot \Delta \vec{r} = f_k \Delta r \cos 180^\circ = -f_k \Delta r = -\mu_k mg \ell.
\]

Therefore

\[
W_{\text{nonconservative}} = \Delta(KE + PE)
\]

\[
\implies -\mu_k mg \ell = (KE + PE)_f - (KE + PE)_i = (0 \text{ J} + 0 \text{ J}) - \left( \frac{mv^2}{2} + 0 \text{ J} \right)
\]

\[
\implies \ell = \frac{\frac{v^2}{2\mu_k g}}{2(0.20)(9.81 \text{ m/s}^2)} = 20 \text{ m}.
\]

c) The normal force does no work since it is always perpendicular to any change in the position vector of the system.

d) The work done by the force of kinetic friction was found in part d) to be

\[
W_{\text{nonconservative}} = -\mu_k mg \ell = -(0.20)(80.0 \text{ kg})(9.81 \text{ m/s}^2)(20 \text{ m}) = -3.1 \times 10^3 \text{ J}
\]

g) The power of the kinetic friction force as the student encounters the rough ground is

\[
P = \vec{f}_k \cdot \vec{v} = (-\mu_k mg \mathbf{i}) \cdot (v_x \mathbf{i}) = -\mu_k mg v_x = -(0.20)(80.0 \text{ kg})(9.81 \text{ m/s}^2)(8.9 \text{ m/s}) = -1.4 \times 10^3 \text{ W}.
\]

Since the velocity of the student decreases over the rough ground, the instantaneous power of the force of kinetic friction becomes less negative — eventually becoming zero when the student stops moving.

### 8.74

a) The angular frequency of the oscillation is

\[
\omega = \sqrt{\frac{k}{m}} \implies k = m \omega^2.
\]

The angular frequency is the coefficient of \( t \) in the argument of the cosine, so \( \omega = 7.00 \text{ rad/s} \). Thus

\[
k = m \omega^2 = (2.00 \text{ kg})(7.00 \text{ rad/s})^2 = 98.0 \text{ N/m}.
\]