76. From Eq. 8-6, we find (with SI units understood)

$$U(\xi) = -\int_0^{\xi} \left(-3x - 5x^2\right) dx = \frac{3}{2}\xi^2 + \frac{5}{3}\xi^3 \ .$$

(a) Using the above formula, we obtain $U(2) \approx 19$ J.

(b) When its speed is $v = 4$ m/s, its mechanical energy is $\frac{1}{2}mv^2 + U(5)$. This must equal the energy at the origin:

$$\frac{1}{2}mv^2 + U(5) = \frac{1}{2}mv_o^2 + U(0)$$

so that the speed at the origin is

$$v_o = \sqrt{v^2 + \frac{2}{m}\left(U(5) - U(0)\right)} \ .$$

Thus, with $U(5) = 246$ J, $U(0) = 0$ and $m = 20$ kg, we obtain $v_o = 6.4$ m/s.

(c) Our original formula for U is changed to $U(x) = -8 + \frac{3}{2}x^2 + \frac{5}{3}x^3$ in this case. Therefore, $U(2) = 11$ J. But we still have $v_o = 6.4$ m/s since that calculation only depended on the difference of potential energy values (specifically, $U(5) - U(0)$).