SAMPLE PROBLEM D

Potential Energy

PROBLEM

A 70.0 kg stuntman is attached to a bungee cord with an unstretched length of 15.0 m. He jumps off a bridge spanning a river from a height of 50.0 m. When he finally stops, the cord has a stretched length of 44.0 m. Treat the stuntman as a point mass, and disregard the weight of the bungee cord. Assuming the spring constant of the bungee cord is 71.8 N/m, what is the total potential energy relative to the water when the man stops falling?

SOLUTION

1. DEFINE

Given: $m = 70.0\ \text{kg}$ $k = 71.8\ \text{N/m}$ $g = 9.81\ \text{m/s}^2$

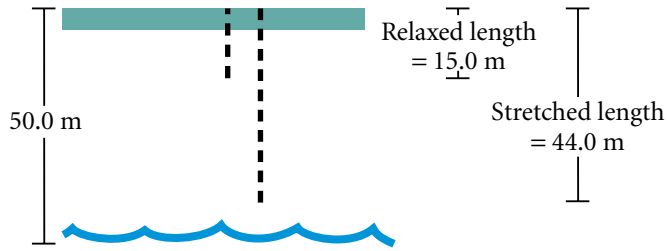
$h = 50.0\ \text{m} - 44.0\ \text{m} = 6.0\ \text{m}$

$x = 44.0\ \text{m} - 15.0\ \text{m} = 29.0\ \text{m}$

$PE = 0\ \text{J}$ at river level

Unknown: $PE_{tot} = ?$

Diagram:



2. PLAN

Choose an equation or situation:

The zero level for gravitational potential energy is chosen to be at the surface of the water. The total potential energy is the sum of the gravitational and elastic potential energy.

$$PE_{tot} = PE_g + PE_{elastic}$$

$$PE_g = mgh$$

$$PE_{elastic} = \tfrac{1}{2}kx^2$$

TIP *Choose the zero potential energy location that makes the problem easiest to solve.*

3. CALCULATE

Substitute the values into the equations and solve:

$$PE_g = (70.0\ \text{kg})(9.81\ \text{m/s}^2)(6.0\ \text{m}) = 4.1 \times 10^3\ \text{J}$$

$$PE_{elastic} = \tfrac{1}{2}(71.8\ \text{N/m})(29.0\ \text{m})^2 = 3.02 \times 10^4\ \text{J}$$

$$PE_{tot} = 4.1 \times 10^3\ \text{J} + 3.02 \times 10^4\ \text{J}$$

$$\boxed{PE_{tot} = 3.43 \times 10^4\ \text{J}}$$

4. EVALUATE

One way to evaluate the answer is to make an order-of-magnitude estimate. The gravitational potential energy is on the order of $10^2\ \text{kg} \times 10\ \text{m/s}^2 \times 10\ \text{m} = 10^4\ \text{J}$. The elastic potential energy is on the order of $1 \times 10^2\ \text{N/m} \times 10^2\ \text{m}^2 = 10^4\ \text{J}$. Thus, the total potential energy should be on the order of $2 \times 10^4\ \text{J}$. This number is close to the actual answer.