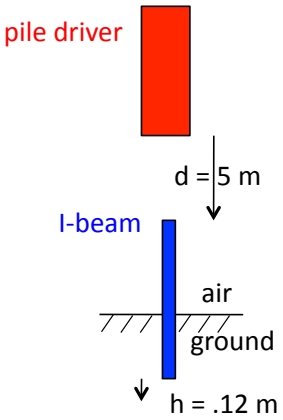
Problem 7.35



A $2.10\text{x}10^3$ kg pile driver drops 5.00 meters before slamming into a I-beam in the ground. The I-beam is driven .120 meters into the ground before coming to rest. Using energy considerations, determine the average force the pile driver exerts on the I-beam.

Although this might not be immediately obvious, what we want to do is track the energy content of the pile driver from the time it starts from rest (v = 0) up in the heavens to the time it comes again to rest (v = 0) after smashing and driving the I-beam. Defining the force from the I-beam as "$\vec{F}_{avg}$" and noticing that gravity does work over the entire "d + h" distance, the Work/Energy Theorem without calculations looks like:

$$W_{net,driver} = W_{gravity} + W_{I-beam}$$

$$\Rightarrow \quad \left(W_{gravity}\right) + \left(W_{I-beam}\right) = \cancel{KE_2}^{\,0} - \cancel{KE_1}^{\,0}$$

$$\Rightarrow \quad \left(\vec{F}_g \bullet \left(\vec{d} + \vec{h}\right)\right) + \left(\vec{F}_{avg,IBeam} \bullet \vec{h}\right) = 0$$

Following through with the calculation, we get:

$$\left|\vec{F}_g\right| \left|\vec{d} + \vec{h}\right| \cos\theta_g + \left|\vec{F}_{avg}\right| \left|\vec{h}\right| \cos\theta_I = 0$$

$$(\ m\ g\ )\ (d + h)\ \cos 0^\circ + F_{avg}\ h\ \cos 180^\circ = 0$$

$$\left(2.10\text{x}10^3\ \text{kg}\right)\left(9.80\ \text{m/s}^2\right)(5.12\ \text{m})\ (1) + \left(F_{avg}\right)(.120\ \text{m})\ (-1) = 0$$

$$\Rightarrow \quad F_{avg} = 8.78\text{x}10^5\ \text{N}$$

And, of course, this force will be upward.