2011 F=ma Exam: Problem 15

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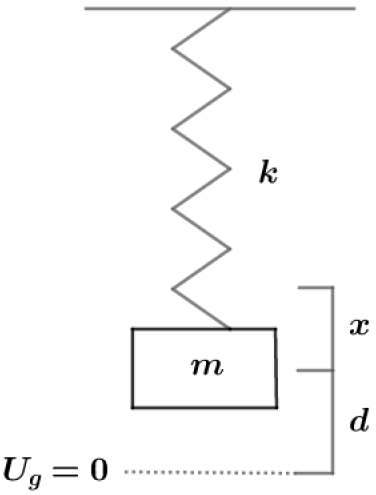

The initial energy of the mass-spring system is

$$E_i = \frac{1}{2}k(x+d)^2$$

where x is the new equilibrium and d is the subsequent displacement. Note we have the initial position of the mass as $U_g = 0$. When the mass passes through the new equilibrium, the energy is

$$E_f = \frac{1}{2}kx^2 + mgd + \frac{1}{2}mv^2$$

From energy conservation,

$$\frac{1}{2}k(x+d)^2 = \frac{1}{2}kx^2 + mgd + \frac{1}{2}mv^2$$
$$kxd + \frac{1}{2}kd^2 = mgd + \frac{1}{2}mv^2$$

Since $kx = mg$,

$$\frac{1}{2}kd^2 = \frac{1}{2}mv^2$$

We could have also gotten this directly using the equivalence of a vertical spring to a horizontal spring with shifted equilibrium. Thus,

$$k = \frac{mv^2}{d^2} = \frac{(0.100\,\text{kg})(0.75\,\text{m/s})^2}{(0.02\,\text{m})^2} = 140\,\text{N/m}$$

so the answer is $\boxed{\text{D}}$.