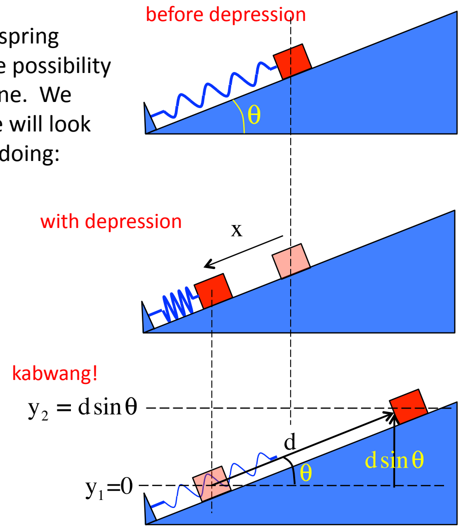
Problem 8.21

As was the case with the previous spring problem (*Problem 8.3*), there is the possibility of inadvertent over-thinking this one. We don't want to do that. As such, we will look at what each part of the system is doing:

To that end, what is happening in this problem?

The spring is being depressed a net distance "x" from its unsprung position. If we put the "y = 0" level for gravitational potential energy at the mass's lowest position, we end up with the set-up shown to the right.



Sooooo, we are left with a spring that is depressed a distance x = .100 meters, and a body that rises a total distance "d" up the incline executing a vertical (y) displacement of "$d\sin\theta$." With that, we can right:

$$\sum KE_1 + \sum U_1 + \sum W_{ext} = \sum KE_2 + \sum U_2$$

$$0 + \left(\frac{1}{2}kx^2\right) + 0 = 0 + mg(d\sin\theta)$$

$$\Rightarrow \quad d = \left[\frac{kx^2}{2mg\sin\theta}\right]$$

$$\Rightarrow \quad d = \left[\frac{(1.40x10^3 \text{ kg})(.100 \text{ m})^2}{2(.200 \text{ kg})(9.80 \text{ m/s}^2)\sin 60^\circ}\right]$$

$$= 4.12 \text{ m}$$

b.) With friction, everything is the same except there is *extraneous work* being done due to friction. We could use N.S.L. to determine the *normal force* (we need that as $f = \mu_k N$, but you've had enough experience with these problems to be able to see that the normal will equal "$mg\cos\theta$." With that, the *Modified Conservation of Energy* relationship becomes:

$$\sum KE_1 + \sum U_1 + \sum W_{ext} = \sum KE_2 + \sum U_2$$

$$0 + \left(\frac{1}{2}kx^2\right) + \vec{F}_g \bullet \vec{d} = 0 + mgd\sin\theta$$

$$\Rightarrow \quad \left(\frac{1}{2}kx^2\right) + \left[-(\mu_k mg\cos\theta)(d)\right] = mgd\sin\theta$$

$$\Rightarrow \quad \frac{1}{2}(1.40x10^3 \text{ kg})(.100 \text{ m})^2 - (.400)(.200 \text{ kg})(9.80 \text{ m/s}^2)(d)\cos 60^\circ$$

$$= (.200 \text{ kg})(9.80 \text{ m/s}^2)(d)\sin 60^\circ = 0$$

$$\Rightarrow \quad d = \frac{\frac{1}{2}(1.40x10^3 \text{ kg})(.100 \text{ m})^2}{(.400)(.200 \text{ kg})(9.80 \text{ m/s}^2)(d)\cos 60^\circ + (.200 \text{ kg})(9.80 \text{ m/s}^2)(d)\sin 60^\circ}$$

$$\Rightarrow \quad d = 3.35 \text{ m}$$