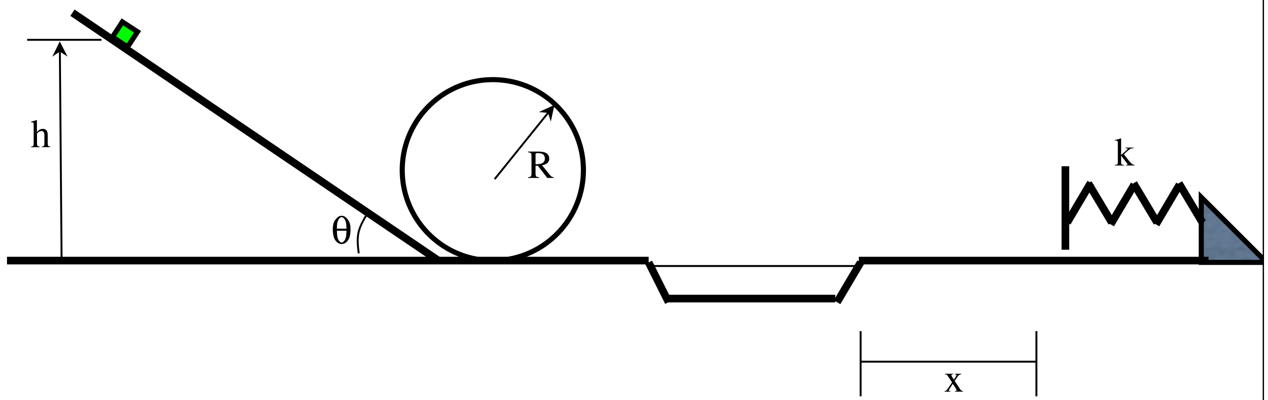
ENERGY PROBLEM FROM HELL
(hear the screams, hee hee)

At a particular instant, a 3 kg block is found to be moving with velocity 4 m/s an unknown distance "h" units above the ground on a 30° frictionless incline. At the bottom of the ramp is a 2 meter radius loop. When the block passes through the top of the loop, it is observed to be moving with a velocity magnitude of 12 m/s (see sketch on next page). The block then passes through a vat of jello where it loses 40 joules of energy, then slides over a 12 meter long frictional surface where f = 2.5 nts. It finally hits a spring where it loses an unknown amount of energy but pushes the spring whose spring constant is 200 nt/m a distance 1.2 meters.

a.) To begin with, what must "h" be?

b.) How much energy must be lost to the collision with the spring?

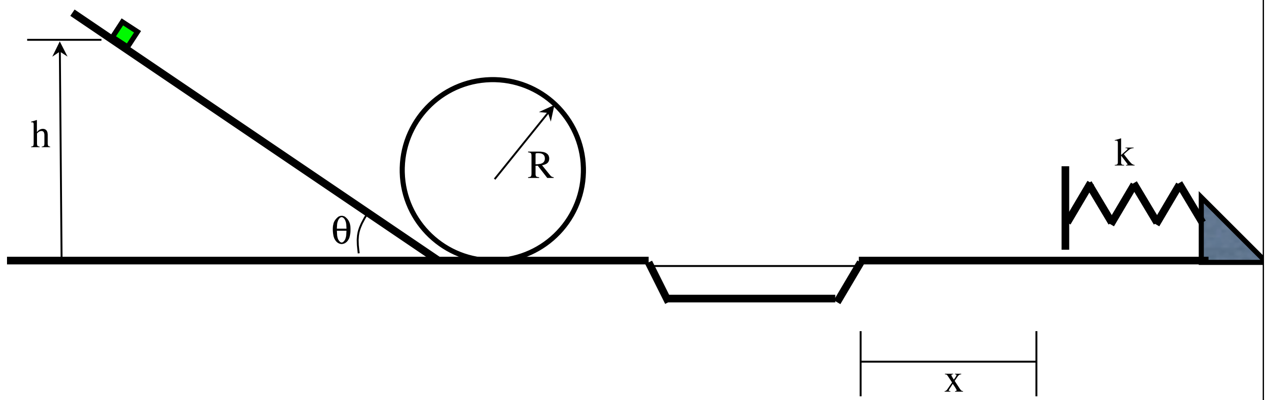
m = 3 kg, initial velocity = 4 m/s, 30 degree frictionless incline, loop radius = 2 meters, velocity through top is 12 m/s, jello vat removes 40 joules of energy, then passes over x=12 meter long friction surface where f=2.5 nts, hits spring losing unknown amount of energy while pushing spring of spring constant 200 nt/m a distance of 1.2 meters.



a.) What is “h?”

a.) You know what’s happening at the top of the arc, so the reasonable thing to do would be to use *conservation of energy* between the initial point and the top of the arc (note that you will NOT have to use N.S.L. and centripetal forces for this).

m = 3 kg, initial velocity = 4 m/s, 30 degree frictionless incline, loop radius = 2 meters, velocity through top is 12 m/s, jello vat removes 40 joules of energy, then passes over x=12 meter long friction surface where f=2.5 nts, hits spring losing unknown amount of energy while pushing spring of spring constant 200 nt/m a distance of 1.2 meters.



a.) What is "h?"

a.) You know what's happening at the top of the arc, so the reasonable thing to do would be to use *conservation of energy* between the initial point and the top of the arc (note that you will NOT have to use N.S.L. and centripetal forces for this).

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

$$\frac{1}{2}mv_1^2 + mgh + 0 = \frac{1}{2}mv_{top}^2 + mg(2R)$$

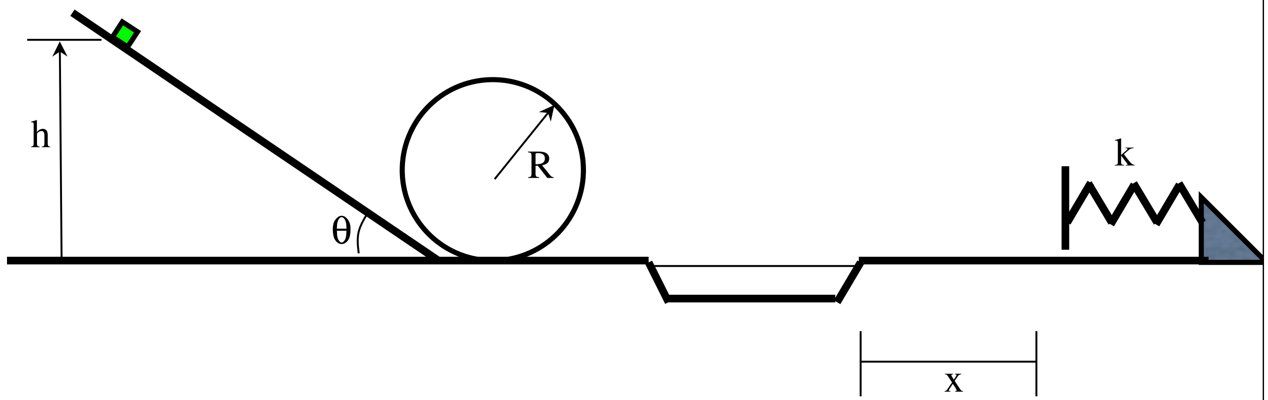
$$\Rightarrow \quad v_1^2 + 2gh = v_{top}^2 + 2g(2R)$$

$$\Rightarrow \quad h = \frac{v_{top}^2 + 4gR - v_1^2}{2g}$$

$$\Rightarrow \quad h = \frac{(12\text{ m/s})^2 + 4(9.8\text{ m/s}^2)(2\text{ m}) - (4\text{ m/s})^2}{2(9.8\text{ m/s}^2)}$$

$$\Rightarrow \quad h = 10.5\text{ m}$$

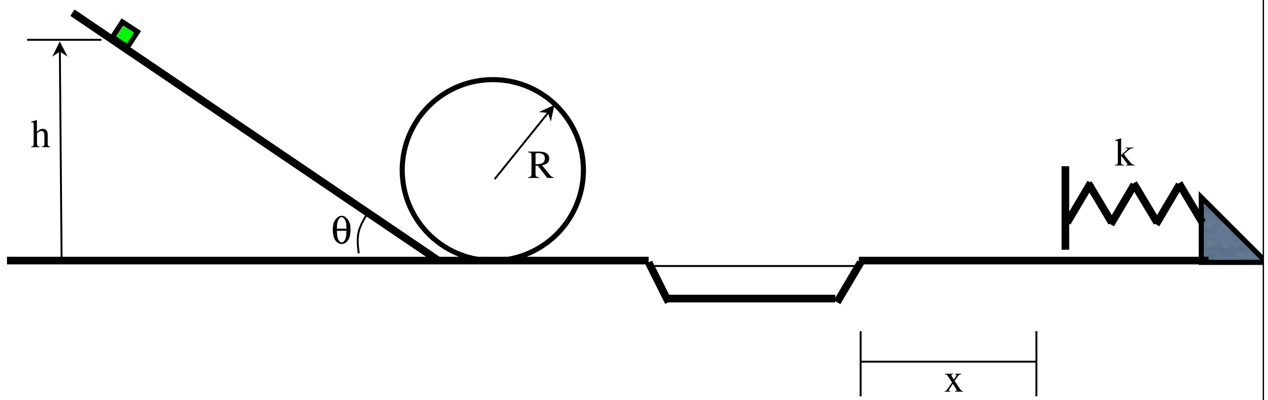
m = 3 kg, initial velocity = 4 m/s, 30 degree frictionless incline, loop radius = 2 meters, velocity through top is 12 m/s, jello vat removes 40 joules of energy, then passes over x=12 meter long friction surface where f=2.5 nts, hits spring losing unknown amount of energy while pushing spring of spring constant 200 nt/m a distance of 1.2 meters.



b.) How much energy is lost in the collision with the spring?

Conservation of energy from start to finish:

m = 3 kg, initial velocity = 4 m/s, 30 degree frictionless incline, loop radius = 2 meters, velocity through top is 12 m/s, jello vat removes 40 joules of energy, then passes over x=12 meter long friction surface where f=2.5 nts, hits spring losing unknown amount of energy while pushing spring of spring constant 200 nt/m a distance of 1.2 meters.



b.) How much energy is lost in the collision with the spring?

Conservation of energy from start to finish:

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

$$\frac{1}{2}mv_1^{\,2} + mgh + \left[(-40\text{ J}) + (-f_{friction}x) + W_{collision}\right] = 0 + \frac{1}{2}kd^2$$

$$\Rightarrow \quad W_{collision} = -\frac{1}{2}mv_1^{\,2} - mgh + 40\text{J} + fx + \frac{1}{2}kd^2$$

$$\Rightarrow \quad W_{collision} = -\frac{1}{2}(3\text{ kg})(4\text{ m/s})^2 - (3\text{ kg})(9.8\text{ m/s}^2)(10.5\text{ m}) + 40\text{J} + (2.5\text{ nt})(12\text{ m}) + \frac{1}{2}(200\text{ nt/m})(1.2\text{ m})^2$$

$$\Rightarrow \quad W_{collision} = -118.7\text{ J}$$