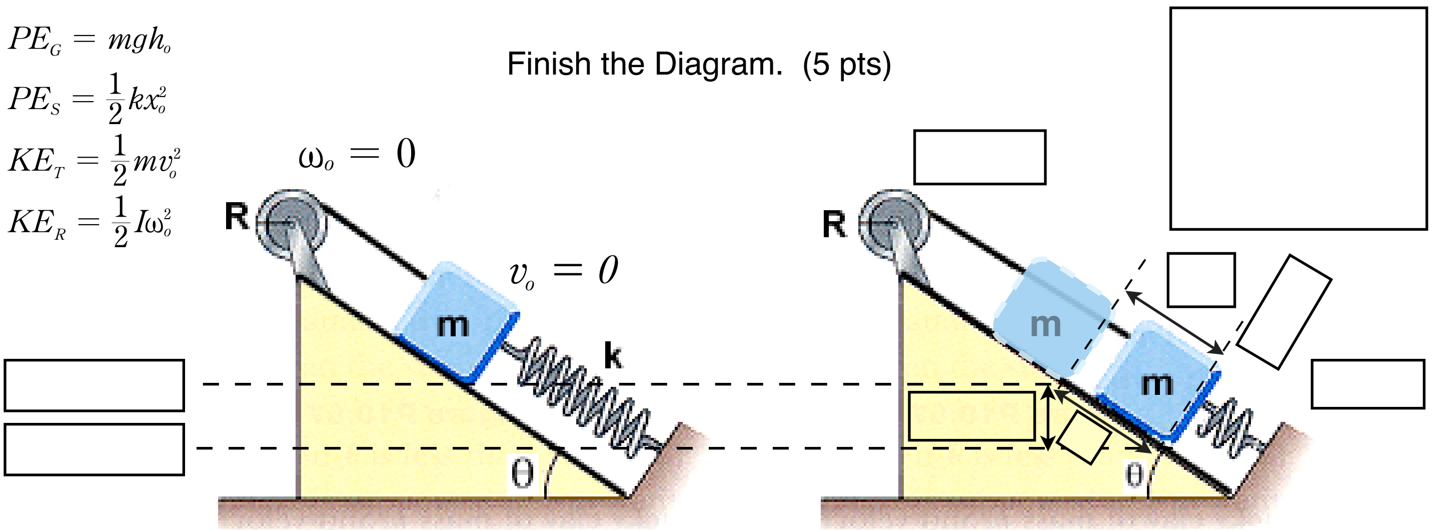
**Physics 195 Chapter 10 Problem 70** 30 pts

The reel shown has radius $R$ and moment of inertia $I$. One end of the block of mass $m$ is connected to a spring of force constant $k$ and the other end is fastened to a cord wrapped around the reel. The reel axle and the incline are frictionless. The reel is wound counterclockwise so that the spring stretches a distance $d$ from its unstretched position and is then released from rest. (a) Find the angular speed of the reel when the spring is again unstretched. (Answer using theta for $\theta$, g for the acceleration due to gravity, and $R$, $I$, $m$, $k$, and $d$, as necessary.) (b) Evaluate the angular speed numerically at this point if

**$I = 1.10\ kg\cdot m^2$, $R = 0.300$ m, $k = 50.0$ N/m, $m = 0.500$ kg, $d = 0.200$ m, and $\theta = 37.0°$.**

$$PE_G = mgh_o$$
$$PE_S = \frac{1}{2}kx_o^2$$
$$KE_T = \frac{1}{2}mv_o^2$$
$$KE_R = \frac{1}{2}I\omega_o^2$$

Finish the Diagram. (5 pts)




Before

After

**Using the Conservation of Energy**

*Energy Before* = *Energy After*

1 pt

$$PE_G + PE_S + KE_T + KE_R = PE_G + PE_S + KE_T + KE_R$$

Which terms cancel and why?

= 1 pt

$$mgd\sin\theta + \frac{1}{2}kd^2 =$$

$$mgd\sin\theta + \frac{1}{2}kd^2 =$$

$$mgd\sin\theta + \frac{1}{2}kd^2 =$$

3 pts

What is the linear to angular conversion?

1 pt

*solve for ω, symbolically* $\omega_f =$

1 pt

*solve for ω, numerically* $\omega_f =$ =

1 pts

1 pt

1 pts

What is the intial energy and what happened to it?

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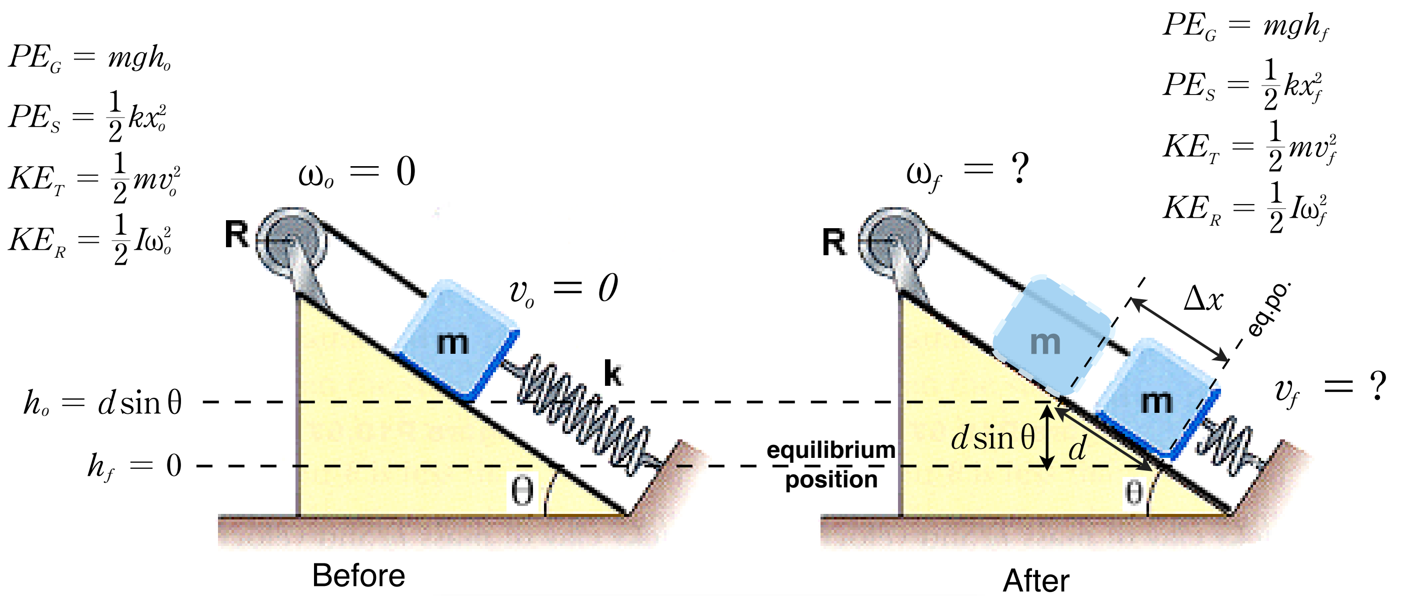


### Using the Conservation of Energy

*The spring is stretched, the block is higher, and has zero linear and angular velocity.*

*The spring is not stretched, the block is lower, and has both linear and angular velocity.*

*Energy Before = Energy After*

$$PE_G + PE_S + KE_T + KE_R = PE_G + PE_S + KE_T + KE_R$$

$v_o = 0$, $\omega_o = 0$, $h_f = 0$, $x_f = 0$

**the box falls a distance $h_o = d\sin\theta$**

$$mgh_o + \frac{1}{2}kx_o^2 + 0 + 0 = 0 + 0 + \frac{1}{2}mv_f^2 + \frac{1}{2}I\omega_f^2$$

*We want to get v in terms of w.* $v = rw$

*the spring travels a distance d.*

$$mgd\sin\theta + \frac{1}{2}kd^2 = \frac{1}{2}m(r\omega_f)^2 + \frac{1}{2}I\omega_f^2$$

$$mgd\sin\theta + \frac{1}{2}kd^2 = \frac{1}{2}(mr^2)\omega_f^2 + \frac{1}{2}I\omega_f^2$$

*Factor and solve for ω*

$$mgd\sin\theta + \frac{1}{2}kd^2 = \frac{1}{2}\omega_f^2(mr^2 + I)$$

$$\omega_f = \sqrt{\frac{2mgd\sin\theta + kd^2}{(mr^2 + I)}}$$

*Becareful, $mr^2$ is not I, m is the mass of the block!*

$$\omega_f = \sqrt{\frac{2(0.5kg)9.8m/s^2(0.2m)\sin 37° + 50Nm(0.2m)^2}{0.5kg(0.3m)^2 + 1.00kg{\cdot}m^2}} = \boxed{1.75\frac{rads}{\sec}\ \text{CW}}$$

*3 sig figs*

*the original $PE_G$ and $PE_S$ is transformed into turning the reel and moving the box.*