PHYS 1901 – Physics 1A (Advanced) Mechanics module

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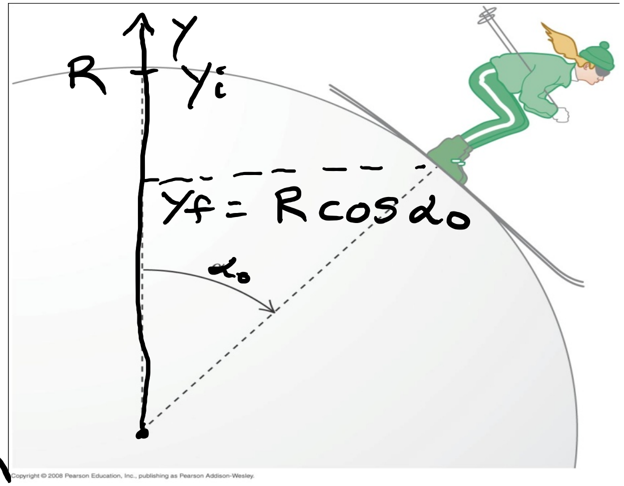
Skier on a snowball

A skier starts at the top of a spherical frictionless snowball, with a very small initial speed.
At what point does he loose contact with the snowball and fly off at a tangent?



W-E theorem

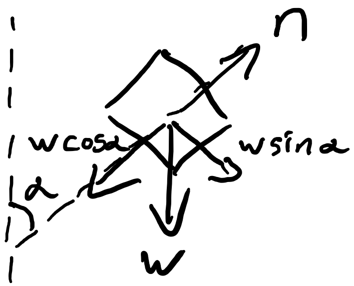
$$\Delta K = W_G$$

Use $W_G = -\Delta U_G$

$$= -mg\Delta h$$

$$= -mg(y_f - y_i) = -mg(R\cos\alpha_0 - R)$$

$$= mgR(1-\cos\alpha_0)$$



For circular motion

Require $F_c = \frac{mv^2}{R} = F_{net,r} = w\cos\alpha - n$

At a critical angle α_0, when the skier is just about to fly off, $n \to 0$

$$F_c = \frac{mv^2}{R} = w\cos\alpha_0 \Rightarrow \frac{mv^2}{R} = mg\cos\alpha_0$$

$$\boxed{v^2 = gR\cos\alpha_0}$$

$$\Delta K = W_G = mgR(1-\cos\alpha_0)$$

$$\tfrac{1}{2}mv^2 = mgR(1-\cos\alpha_0)$$

$$\boxed{v^2 = 2gR(1-\cos\alpha_0)}$$

$$\cos\alpha_0 = 2(1-\cos\alpha_0)$$

$$\cos\alpha_0 = 2/3$$

Chapter

7

Potential Energy and Energy Conservation

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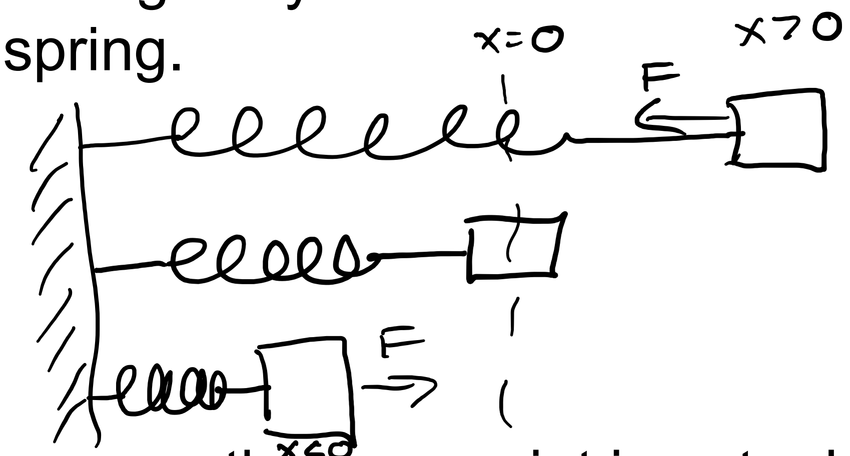
Springs and Potential Energy

We can use a similar argument to gravity to define the **elastic potential energy** stored in a spring.



Hooke's law

$$F = -kx$$

$$U_E(x) = \frac{1}{2} k x^2$$

Unlike gravitational potential energy, the zero-point is not arbitrary as *$U_E(x=0) = 0$.*

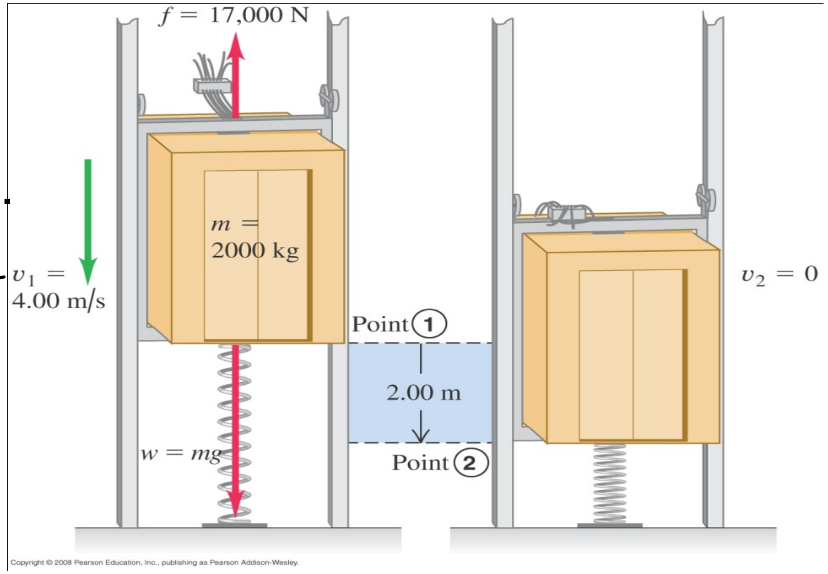
The total (mechanical) energy is conserved so

$$W_E = -\Delta U_E$$

Springs and gravity

Example 7.9

Elevator cable is broken, and the elevator is falling.
Brake is applying a frictional force.
Spring must stop elevator in 2.00m from v = 4.00 m/s.
What is the spring constant?



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$K_1 = \frac{1}{2}mv_1^2 = \frac{1}{2}(2000\,kg)(4.00\,m/s)^2 = 1.6\times10^4\,J$

$K_2 = 0$

$\Delta K = K_2 - K_1 = -1.6\times10^4\,J$

$\Delta K = W_{total}$ W-E theorem

$-1.6\times10^4\,J = \underbrace{W_f}_{-ve} + \underbrace{W_g}_{+ve} + \underbrace{W_E}_{-ve} \Rightarrow W_E = \Delta K - W_f - W_g$

$W_f = -f_k s = -(17\,000\,N)(2.00\,m) = -3.4\times10^4\,J$

$W_g = -\Delta U_g = -mg(y_2 - y_1) = (2000\,kg)(9.80\,m/s^2)(2.00\,m) = 3.92\times10^4\,J$

$W_E = -2.12\times10^4\,J = -\Delta U_E = -(U_2 - \cancel{U_1}^{=0}) = -\frac{1}{2}k(2.00\,m)^2$

$k = 1.06\times10^4\,N/m$