Discussion 6b : Energy and Energy Conservation

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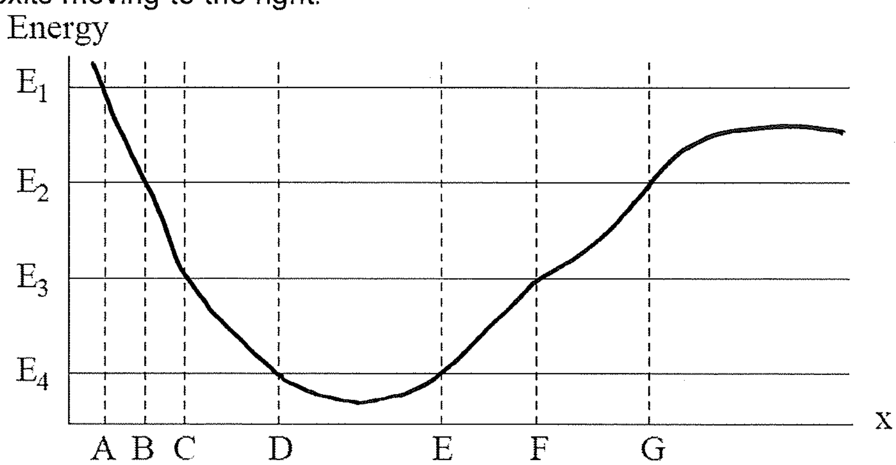
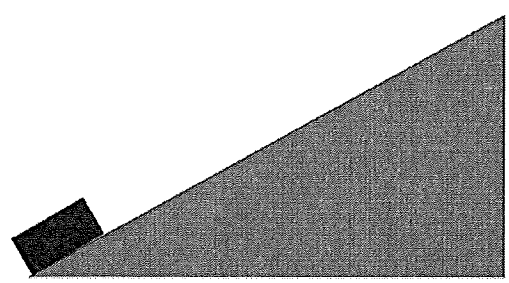
Goal: Discussing and understanding force, energy, energy conservation, and work.

A) Below are a set of axes on which you will sketch a potential energy curve. From an experiment you discover:

1. A particle with energy E4 oscillates between positions D and E.
2. A particle with energy E3 oscillates between positions C and F.
3. A particle with energy E2 oscillates between positions B and G.
4. A particle with energy E1 enters from the right, "bounces" at A and then exits moving to the right.



B) A 2.0 kg block, with an initial speed of 4.0 m/s, starts out traveling up a rough 30° incline. At some distance up the incline it comes momentarily to a stop and then slides back down. The block has a speed of 2.0 m/s when it slides past the initial starting point. (Assume little g is 10 m/s^2).



1. How much work was done by gravity on the block?

The block starts and stops at the same spot and gravity is conservative so $W_g = 0$

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2. How much work was done by friction on the block?

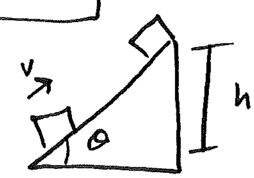
Friction is Not conservative so we have

$KE_i = KE_f + W_{lost}$ (or $KE_i - W_{lost} = KE_f$ whichever makes more sense to you)

so $W_{lost} = KE_i - KE_f = \frac{1}{2} 2 \cdot 4^2 - \frac{1}{2} 2 \cdot 2^2 = 16 - 4 = 12 J$

but energy is lost by the block so Work by friction on the block is negative or $\boxed{W_f = -12J}$

3. How far up the incline did the block travel?



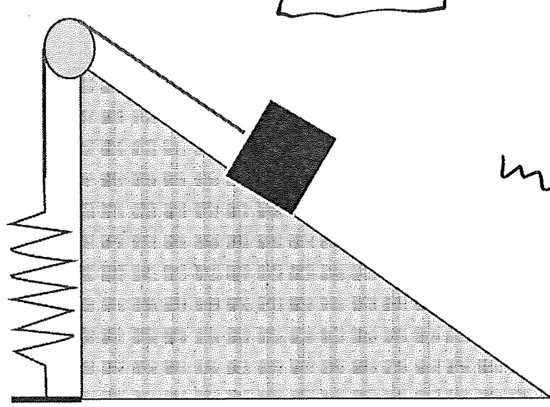
We can use energy conservation again!

$KE = PE + W_{lost}$ but only travel up, not up and down, so $W_{lost} = |W_f|/2$ so $h = x \sin\theta$

$\frac{1}{2} m v_i^2 = mgx \sin\theta + 6 \Rightarrow \frac{1}{2} 2 \cdot 4^2 - 6 = (2 \cdot 10 \cdot \sin 30)\, x$

$10 = 10x \Rightarrow \boxed{x = 1m}$

C) A massless spring with an equilibrium length of 2.0 m and spring constant 200 N/m is mounted horizontally as shown in the figure at right and is initially at its equilibrium length. Attached to the spring is a massless rope which rises vertically up and around a massless, frictionless pulley and back down (parallel to the surface) to a mass of 25 kg. The angle of slide is 30° above horizontal. All surfaces are frictionless. Initially the block is held in place by a hand but then the hand is removed. Gravity acts down with g = 10 m/s^2.



1. Write down qualitatively what you think will happen.

Will oscillate on side of ramp.

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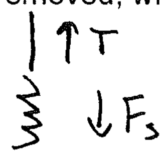
2. Just the instant after the hand is removed, what is the tension in the rope?

0 N ⇒



spring is massless, so

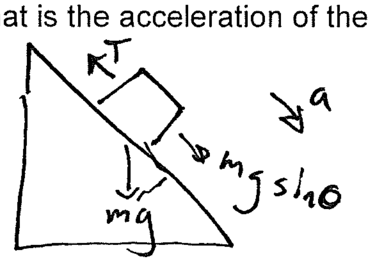
$T - F_s = (0)a$ so

$T = F_s$, but the spring is unstretched, so $T = 0$ N

3. The block now slides along the surface a distance of 0.50 m. What is the magnitude of the tension in the rope?

$T = F_s = k\Delta x = 200 \cdot 0.5 = \boxed{100\,N}$

4. What is the acceleration of the block? Is it speeding up or slowing down?



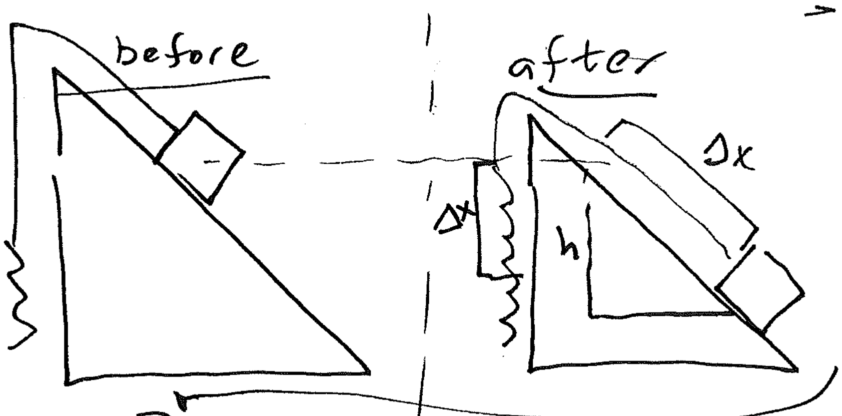
so $mg\sin\theta - T = ma$

or $a = g\sin\theta - \frac{T}{m}$

$a = 10 \cdot \sin 30° - \frac{100}{25} = 5 - 4 = \boxed{1\,m/s^2}$

so speeding up down the ramp!

5. Using the conservation of energy principle determine how fast is the block sliding at this point?



→ Before, it has only ~~kinetic~~ potential energy.

After, the potential is turned into kinetic and spring potential!

or

$PE_g = KE + PE_s \Rightarrow mgh = \frac{1}{2}mv^2 + \frac{1}{2}k\Delta x^2$

$\Delta x \sin\theta = h$ so $\frac{1}{2}mv^2 = mg\Delta x \sin\theta - \frac{1}{2}k\Delta x^2$

$v^2 = 2g\Delta x \sin\theta - k\frac{\Delta x^2}{m} \Rightarrow v = \sqrt{2 \cdot 10 \cdot \frac{1}{2} \cdot \frac{1}{2} - 200 \cdot \left(\frac{1}{2}\right)^2 \cdot \frac{1}{25}} = \sqrt{5-2} = \sqrt{3}$ m/s