Conservation of Energy

September 8, 2015 1:20 PM

Conservation of Energy Law: Energy cannot be created or destroyed. It can only change form.

$$E_i = E_f$$

Total Energies

$E_T = PE + KE$

This tells us that the total initial Energy in a closed system is equal to the total final Energy.

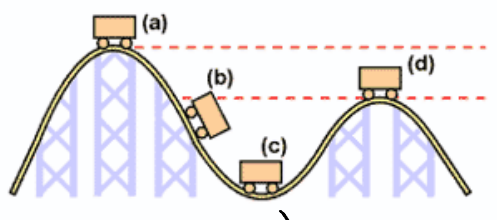
For most of our questions we will just be working with Gravitational Potential Energy and Kinetic Energy.

https://phet.colorado.edu/sims/html/energy-skate-park-basics/latest/energy-skate-park-basics_en.html

Lets look at our roller coaster example again:

Example: Find the Potential and Kinetic Energies at the following heights a=12m, b=7m, c=0m, d=8m. Assume that the roller coaster is on a frictionless surface, that there is no air resistance and that at that the velocity at point a is $v_a = 0$.

$m = 63\ kg$



$-e^{i\pi}$

$i = \sqrt{-1}$

a) $KE_A = 0$

$PE_A = mgh$

$= (63)(9.8)(12)$

$= 7409\ J$

b) $KE_B =$

$PE_B = mgh$

$= (63)(9.8)(7)$

$= 4322\ J$

$KE = E_T - PE$

c) $PE_C = 0$

$E_T = PE + KE$

$KE_C = 7409\ J$

d) $PE_D = (63)(9.8)(8)$

$= 4939\ J$

$KE = 7409 - 4939$

$KE_D = 2470\ J$

$= (63)(9.8)(12)$
$= 7409\,J$

$E_T = PE_A + kE_A$
$= 7409\,J$

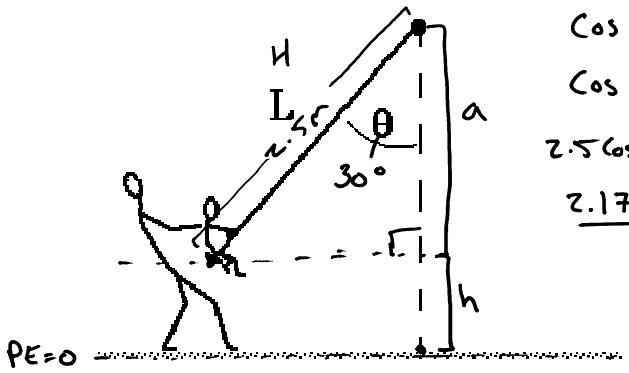
$= 4322\,J$

$KE_B = E_T - PE_B$
$= 7409 - 4322$
$= 3087\,J$

$KE_C = 7409\,J$

$KE_D = 2470\,J$

Example: A parent pulls a child back on a frictionless swing. The length of the swing chain is 2.5m and the parent pulls the child back 30°. What velocity does the child attain at the bottom of the swing?



$\cos\theta = \frac{a}{H}$

$\cos 30 = \frac{a}{2.5}$

$2.5\cos 30 = a$

$2.17m = a$

$2.5 = a + h$

$2.5 - a = h$

$h = 0.335m$

$E_i = PE_i + kE_i$ ($v = 0$, $kE_i = 0$)

$= mgh + \frac{1}{2}mv^2$

$= (m)(9.8)(0.335)$

$E_i = m(3.28)$

$E_f = PE_f + kE_f$ ($h = 0$, $PE_f = 0$)

$= mgh + \frac{1}{2}mv_f^2$

$E_f = \left(\frac{1}{2}\right)(m)v_f^2$

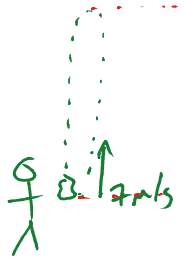
$E_i = E_f$

$m(3.28) = \frac{1}{2}mv_f^2$

$\sqrt{2(3.28)} = \sqrt{v_f^2}$

$v_f = 2.56\,m/s$

Let's revisit one of our kinematics problems.
If you throw a rock up with a velocity of 7m/s. What will be its maximum height?



$E_i = PE_i + kE_i$

$E_i = \frac{1}{2}mv^2$

$E_f = PE_f + kE_f$

$E_f = mgh$

$\frac{1}{2}mv^2 = mgh$

$\frac{v^2}{2g} = h$

$h = 2.5m$

Non-conserved Systems: In the real world we do not have perfect frictionless surfaces. Friction removes energy from our system and changes it into heat, sound, light, etc.

$E_{T_i} = E_{T_f} + E_{lost}$

Example: A skateboarder approaches a 1.3m high ramp with a velocity of 7.3m/s. He reaches a maximum height of 2.1m. $m = 73\,kg$

a) How much energy is lost due to air resistance and friction between the ramp and the wheels and within the wheels.

$v = 0\,m/s$ ($v = 0$)

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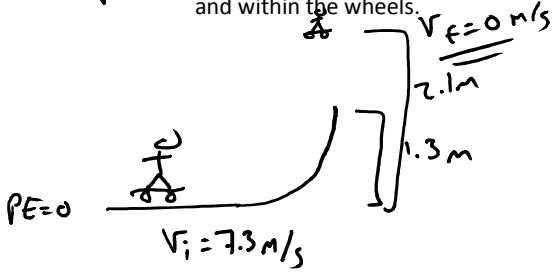

$E_i = PE_i + KE_i$

$= \frac{1}{2}mv_i^2$

$= \frac{1}{2}(73)(7.3)^2$

$= 1945\ J$ → Energy lost

$E_f = PE_f + KE_f$ (v=0)

$= mgh$

$= (73)(9.8)(2.1)$

$= 1502\ J$

$E_{lost} = E_i - E_f$

$= 443\ J$

a) What type of energy could have been created to explain this loss of energy?

Thermal, Sound, Resistance, EM waves,

b) assume all Energy lost went into heating up the four 20g steel wheels. How much did they heat up. $[C_{steel} = 350]$

$Q = mC\Delta T$

$443 = (0.08)(350)\Delta T$

$\frac{443}{(0.08)(350)} = \Delta T$

$1.6^\circ C = \Delta T$