EFFICIENCY CALCULATIONS

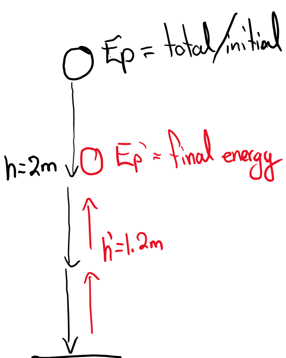
The 2nd Law of Thermodynamics states that no energy transfer is 100% efficient. During energy transfers some energy is always converted into a form that is not useful. **Heat is usually a by product of most energy transformations owing to friction.**

Efficiency Calculations			
% Efficiency= $\frac{\text{Output Energy}}{\text{Input Energy}}$ x 100		**Energy = Joules (J)** **Efficiency has no units (%)**	
Ep= mgh	**m is mass in kg**	**Ek=1/2 m v^2**	**v is velocity in m/s**
	g is gravity 9.8 m/s/s		**m is mass in kg**
	h is the height in meters		

Output and Input energy may be given to you in a problem, but more often they need to be calculated using E_p and E_k. Efficiency measures the percentage of initial energy (input energy) is converted into the intended energy (output energy)

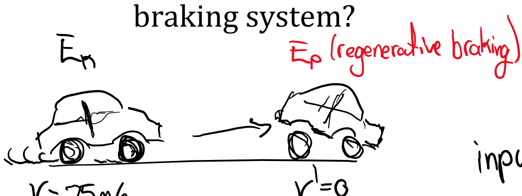
Example Problems:

Ex1. A ball with a mass of 0.5 kg is dropped from a height of 2 m. It bounces back up to a height of 1.2 m, with the rest of the energy lost to heat during the collision with the ground. What is the efficiency of the energy transformation into the ball's rebound height? How much energy was lost as friction?



Step 1. Determine total (input) and final (output) energy:	*Step 2: Calculate energy efficiency:*	*Step 3: Calculate how much energy was lost to friction*
m = 0.5kg g = 9.81m/s^2 h = 2m h' = 1.2m Ep = input Ep' = output Input/Total E Ep = mgh =(0.5)(9.81)(2) = 9.81J Output E. Ep' = mgh' =(0.5)(9.81)(1.2) =5.886 ≈5.89J	$\%E_{ff} = \frac{\text{output E}}{\text{input E}} \times 100$ $= \frac{5.89J}{9.81J} \times 100$ $= 60.0\%$	Energy loss = input − output = 9.81J − 5.89J = 3.92J

Ex2. A 1,500 kg car traveling at 25 m/s comes to a stop using brakes. The initial kinetic energy of the car is converted to heat energy in the brake system. Only 80,000 J of the initial energy is recovered as useful energy (e.g., regenerative braking). What is the efficiency of the regenerative braking system?



Ek = input
Ep = output = 80,000J
m = 1500kg
v = 25 m/s

input = $E_K = \frac{1}{2}mv^2$
$= \frac{1}{2}(1500)(25)^2$
$= 468750J$

$\%Eff = \frac{\text{output}}{\text{input}} \times 100$
$= \frac{80,000J}{468750J} \times 100$
$= 17.1\%$

Practice Questions:

1. What does it mean to be 80% efficient? How much percentage of the input energy was converted to usable energy? ____________. How much energy was wasted? _________.

2. 84 J of elastic potential energy is stored in a compressed spring. The spring is 75% efficient in transforming the elastic potential energy into kinetic energy that will be used when the spring is released to catapault a 0. 5 kg block. What will be the kinetic output energy?

3. In cellular respiration 1 mol of glucose is broken down in the following reaction:

   $$\mathbf{C_6H_{12}O_6 + 6O_2 \longrightarrow 6H_2O + 6CO_2 + 2870.0\ kJ}$$

   This energy is then stored in ATP for the body's use whenever it needs energy.

   $$\mathbf{2870\ kJ \longrightarrow 36\ ATP + 1098\ kJ\ of\ stored\ chemical\ energy}$$

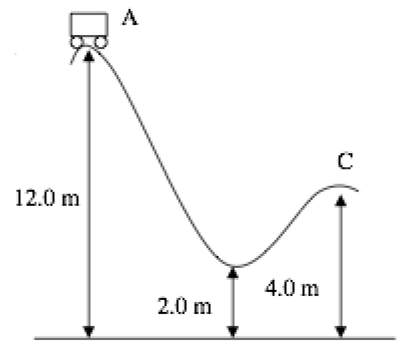
   What is the efficiency of the energy transformation involved in making ATP?

   What is the efficiency of the energy transformation involved in making stored chemical energy?

   How much energy was wasted?

4. Jack pedaled up a hill and gained a vertical distance of 25 m. Then he turned around and coasted down the hill, reaching a speed of 13 m/s at the bottom of the hill. The combined mass of Jack and his bike is 68 kg. What was the efficiency of the transformation of his gravitational potential energy into kinetic energy, going down the hill?

5. The roller coaster shown below has a mass of 525 kg and is travelling at 2.10 m/s at point A, and is later travelling at 12.7 m/s at the lowest point. What is the efficiency of the roller coaster between point A and the lowest point?



6. This time the roller coaster has an efficiency of 41%. If the roller coaster shown below has a mass of 525 kg and is travelling at 2.10 m/s at point A:
   a. what will its speed be at point C?

   b. what will its speed be at the lowest point?

7. An 80.0 kg student running at 3.50 m/s grabs a rope that is hanging vertically. How high will the student swing if it is 30% efficient?