



7.3 Efficiency and Energy



Efficiency describes how well energy is converted from one form into another. A process is 100% efficient if no energy is “lost” due to friction, to create sound, or for other reasons. In reality, no process is 100% efficient.

Efficiency is calculated by dividing the output energy by the input energy. If you multiply the result by 100, you will get efficiency as a percentage. For example, if the answer you get is 0.50, you can multiply by 100 and write your answer as 50%.

$$\text{Efficiency} = \frac{\text{Output energy (J)}}{\text{Input energy (J)}}$$

EXAMPLE

You drop a 2-kilogram box from a height of 3 meters. Its speed is 7 m/s when it hits the ground. How efficiently did the potential energy turn into kinetic energy?

Looking for	Solution
You are asked to find the efficiency.	
Given	
The mass is 2 kilograms, the height is 3 meters, and the landing speed is 7 m/s.	$E_p = (2 \text{ kg})(9.8 \text{ m/s}^2)(3 \text{ m}) = 58.8 \text{ J}$ $E_k = (1/2)(2 \text{ kg})(7 \text{ m/s})^2 = 49 \text{ J}$
Relationships	
Kinetic energy = $1/2mv^2$ Potential energy = mgh Efficiency = (output energy)/(input energy)	The input energy is the potential energy, and the output energy is the kinetic energy. $\text{Efficiency} = (49 \text{ J})/(58.8 \text{ J}) = 0.83 \text{ or } 83\%$ The efficiency is 0.83 or 83% (0.83×100).

PRACTICE

- Engineers who design battery-operated devices such as cell phones and MP3 players try to make them as efficient as possible. An engineer tests a cell phone and finds that the batteries supply 10,000 J of energy to make 5500 J of output energy in the form of sound and light for the screen. How efficient is the phone?
- What's the efficiency of a car that uses 400,000 J of energy from gasoline to make 48,000 J of kinetic energy?
- A 1000.-kilogram roller coaster goes down a hill that is 90. meters tall. Its speed at the bottom is 40. m/s.
 - What is the efficiency of the roller coaster? Assume it starts from rest at the top of the hill.
 - What do you think happens to the “lost” energy?
 - Use the concepts of energy and efficiency to explain why the first hill on a roller coaster is the tallest.
- You see an advertisement for a new free fall ride at an amusement park. The ad says the ride is 50. meters tall and reaches a speed of 28 m/s at the bottom. How efficient is the ride? Hint: You can use any mass you wish because it cancels out.
- Imagine that you are working as a roller coaster designer. You want to build a record-breaking coaster that goes 70.0 m/s at the bottom of the first hill. You estimate that the efficiency of the tracks and cars you are using is 90.0%. How high must the first hill be?