Efficiency Problems—Additional Practice

Efficiency is the ratio of the useful energy output of a device to the energy input required to operate the device. To determine the efficiency and percent efficiency, we can use the following equations:

$$\text{eff} = \frac{E_{out}}{E_{in}} \text{ and } \% \text{ eff} = \frac{E_{out}}{E_{in}} \times 100\%$$

where eff is the efficiency, E_{out} is the useful energy output, and E_{in} is the energy input. We can also use power to determine the efficiency and percent efficiency of an energy-transforming device in the following equations:

$$\text{eff} = \frac{P_{out}}{P_{in}} \text{ and } \% \text{ eff} = \frac{P_{out}}{P_{in}} \times 100\%$$

where eff is the efficiency, P_{out} is the useful power output, and P_{in} is the power input. Solve each of the following problems in the space provided. Be sure to express your answers properly.

Sample Problem

A person exerts a power of 165 W in lifting a 10.0 kg object vertically a distance of 3.0 m in a time of 2.0 s. What is the percent efficiency of the lift?

P_{in} = 165 W
m = 10.0 kg
g = 9.8 N/kg
h = 3.0 m
$E_{out} = E_g$
E_g = ?
$E_g = mgh$
= (10.0 kg)(9.8 N/kg)(3.0 m)
= 294 J

E_{out} = 294 J
Δt = 2.0 s
P_{out} = ?

$$P_{out} = \frac{E_{out}}{\Delta t}$$
$$= \frac{294 \text{ J}}{2.0 \text{ s}}$$
$$= 147 \text{ W}$$

$$\% \text{ eff} = \frac{P_{out}}{P_{in}} \times 100\%$$
$$= \frac{147\,\text{W}}{165\,\text{W}} \times 100\%$$
$$= 89\%$$

The percent efficiency of the lift is 89%.

1. A 1.2-kW electric kettle takes 5.0 min to bring one litre of water from 20°C to the boiling point. If it requires 3.4×10^5 J of thermal energy to perform this task, what is the kettle's efficiency?

2. A car's engine is rated at 225 hp. If the engine is 25% efficient, how much work can it do in 6.0 s? (1 hp = 746 W)

3. A pulley system is 78% efficient. If the system raises a 42-kg object vertically a distance of 8.0 m, how much energy does the operator of the pulley use?

4. A solar panel is 12% efficient. How much light energy falls on the panel each minute if the panel supplies 2.8 W of power?

5. An electric winch exerts a force of 2.3×10^3 N in pulling an 8.0×10^2-kg boat along a marine railway for 11 m. At the end of the ramp, the boat is 2.0 m above the water level. What is the efficiency of the ramp?