PHYSICS 11

EFFICIENCY

Efficiency is the ratio of useful energy or power produced to the total amount of energy or power used

Efficiency is given by the formulae:

$$Eff = \frac{Energy\ output}{Energy\ input}$$

$$Eff = \frac{Power\ output}{Power\ input}$$

$$Eff = \frac{W_{out}}{W_{in}} \times 100$$

$$Eff = \frac{P_{out}}{P_{in}} \times 100$$

"The washing machine is very energy efficient. I just wish Frank was!"

Example 1: A 1500-Watt hair dryer has a thermal power output of only 1200 W because some energy goes to moving air and making sound. Find the efficiency of the hair dryer.

Example 2: The annual natural gas consumption for heating a small house is equivalent to 1.2×10^{11}J. If the furnace has an efficiency of 85%, how much energy is transferred to the house? How much energy is wasted?

Efficiency of Machines

When comparing machines, we calculate their efficiency by:

$$Eff = \frac{work\ done\ by\ the\ machine}{work/energy\ needed\ to\ operate\ the\ machine} \times 100$$

Machines are never 100% efficient.
Any machine with moving parts loses some energy to friction in the form of heat, sound or light.

Recall:

$W = Fd$

$W = F\cos\theta d$

$W = \Delta KE$

$W = \mathrm{P}\Delta\mathrm{t}$

$W = Q = mc\Delta T$

$W = \Delta PE$

Example 3: A lift is able to carry a load of 1.0×10^3 kg at a velocity of 1.5 m/s [up]. Given that the motor driving the lift has an input power of 20 kW, calculate the efficiency of the lift.

An Alternative Unit of Energy

→ **kW· h = kilowatt hour = a large unit of energy**

$$1\,\text{kW}\cdot\text{h} = 3.6 \times 10^6\,\text{J}$$

→ Physiologists, dieticians, and professionals in other health-related fields usually measure energy in **kilocalories [kcal]** = food calories. One kilocalorie is the amount of heat required to raise the temperature of 1.0 kg of water by 1°C: **1 kcal = 4.187 kJ.**

Examples:

1. Calculate the energy consumed by 150-Watt computer that is used for 2.0 hours and 250-Watt laser printer that is used for 10.0 minutes. Give your answer in kWh.

2. Calculate the energy consumed making a breakfast for one person: oatmeal (microwave oven, 1000 W, 2.0 minutes), toast (toaster 1400 W, 1.0 minute), and a fruit smoothie (blender, 385W, 1.0 minute). Give your answers in Joules and in kWh.

3. A cell-phone charger rated at 5.0 W has an efficiency of 60%. If it takes 90 minutes to charge the phone, how much energy is transferred to the phone? How much energy is waste energy? Give your answer in Joules and in kWh.

4. The energy consumption for walking up the stairs is 0.1187kcal/minute (per 1.0 kg of body mass). Calculate the power of a 75.0-kg person climbing the stairs.

5. Calculate the annual consumption in kWh, of a hair dryer that is rated at 1440 W and is used for 7.0 minutes every day.

6. A 60.0-W incandescent light bulb runs continuously for 100 days.
   A) Calculate the amount of energy used in Joules and kilowatt-hours.
   B) How much heat is produced if the bulb has efficiency of 5.0%?

7. If you ran a washing machine (512W) and an electric clothes dryer (5000W) for1.5 hours each day:
   A) How much energy do the two appliances use in one day?
   B) How much energy do the two appliances use in one year?
   C) How much is the cost of operating these two appliances a year if the current rate is 12.1 cent/kWh?