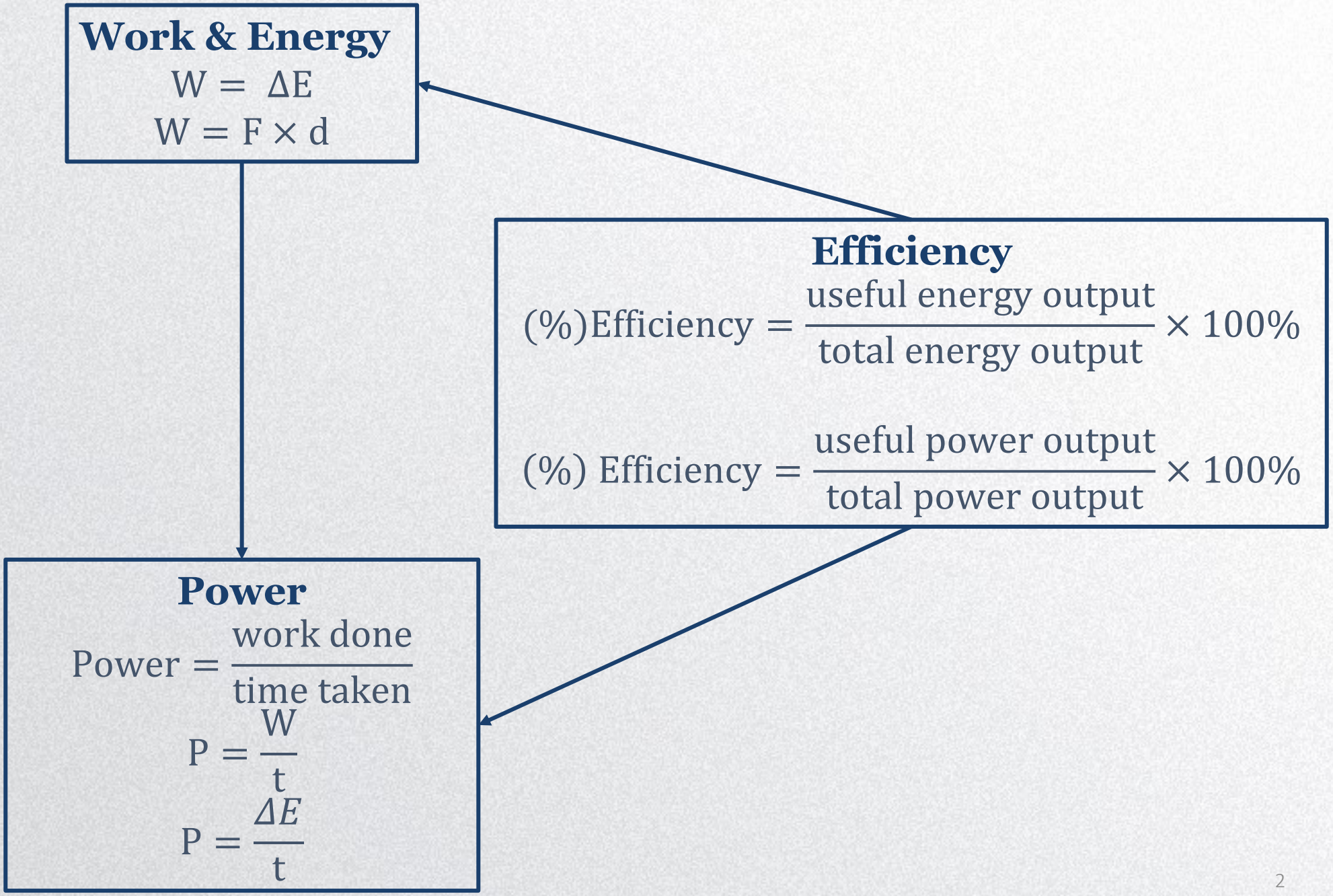
Energy, work and power


Work & Energy
W = ΔE
W = F × d
Efficiency
(%)Efficiency = useful energy output / total energy output × 100%
(%) Efficiency = useful power output / total power output × 100%
Power
Power = work done / time taken
P = W / t
P = ΔE / t

Work

- **Work done is the amount of energy transferred**
- When a force moves an object through a distance, work is done on the object and energy is transferred.
- The force does “work” to move the object and energy is transferred mechanically from one store to another.

Work

$$W = \Delta E$$

$$\mathbf{W = F \times d}$$

where

W = work done (J)

ΔE = energy transferred(J)

F = force (N)

d = **distance moved in the direction of the force** (m)

Efficiency

The efficiency of any device is defined as:

$$(\%)\text{Efficiency} = \frac{\text{useful energy output}}{\text{total energy output}} \times 100\%$$

$$(\%)\text{Efficiency} = \frac{\text{useful power output}}{\text{total power output}} \times 100\%$$

- Efficiency is given as **a percentage**, or **a decimal**.
- Total energy output = total energy input because of the conservation of energy.
- The efficiency can never be equal to or higher than 100%, since some energy is always wasted.

Efficiency

Study question #1:

A toaster transfers 216000 J of energy electrically from the mains. 84000 J of energy is transferred to the bread's thermal energy store. Calculate the efficiency of the toaster.

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$$efficiency = \frac{useful\ energy\ output}{total\ enegy\ output} \times 100\% = \frac{84000}{216000} \times 100\% = 38.888...\% = 39\%$$

Efficiency

Study question #2:

An electrical device wastes 420 J of energy when it has an input energy of 500 J. Calculate the efficiency of the device.

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$$Useful\ energy\ output = 500\ - 420 = 80\ J$$

$$efficiency = \frac{useful\ energy\ output}{total\ enegy\ output} \times 100\% = \frac{80}{500} \times 100\% = 16\%$$

Efficiency

Study question #3:

An electrical kettle has an efficiency of 76%. 2500 J of energy is transferred from the mains to the kettle every second. When the kettle is full, it needs to transfer 418 000 J of energy to the thermal energy store of the water to boil it. How long does a full kettle need to be switched on for in order to boil the water? Use 2 methods.

Efficiency

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Method 1:

$$Total\ thermal\ energy = \frac{418000}{0.76} = 550\,000\ J$$

$$\frac{550000}{2500} = 220\ s$$

Efficiency

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Method 2:

$$Usefully\ transferred\ to\ the\ thermal\ energy\ store\ of\ the\ water$$
$$= 2500 \times 0.76 = 1900J$$

$$\frac{418000}{1900} = 220\ s$$