

Part A: Thinking About Power

1. Two cranes each lift identical 500 kg beams to the top of the same building. Crane X takes 40 s and crane Y takes 20 s.

- Which crane does more work on its beam? Explain.
- Which crane has more power? How many times more? Explain.

a. The same work. Both lift the same mass the same height, so $W = mgh$ is the same.

b. Crane Y, 2 times more. $P = W/t$: same work in half the time means twice the power.

2. A microwave label says 1,100 W. Explain what this number means in terms of joules and seconds. Then explain how you can tell whether the letter W in a problem stands for work or for watts.

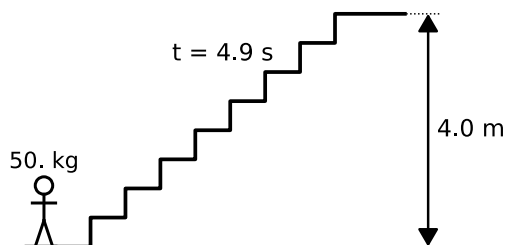
1,100 W means the microwave transfers **1,100 J of energy every second** ($1 \text{ W} = 1 \text{ J/s}$).

Work is a variable, written in italics (W) and measured in joules. The watt is a unit (W) that comes after a number, like 1,100 W. Context tells you which one is meant.

Part B: Calculating Power

Show knowns, equation, substitution with units, and answer. Use $g = 9.8 \text{ m/s}^2$.

3. André runs up a flight of stairs as shown, at a steady pace.



- How much work does he do against gravity?
- What is his power?

Knowns: $m = 50. \text{ kg}$, $h = 4.0 \text{ m}$, $t = 4.9 \text{ s}$

a. $W = mgh = (50. \text{ kg})(9.8 \text{ m/s}^2)(4.0 \text{ m}) = \mathbf{1,960 \text{ J}}$ ($\approx 2.0 \times 10^3 \text{ J}$)

b. $P = W/t = 1,960 \text{ J} / 4.9 \text{ s} = \mathbf{400 \text{ W}}$

4. A 9.0 W LED bulb is left on for 3.0 hours. How much energy does it transfer?

Convert time: $t = 3.0 \text{ h} \times 3,600 \text{ s/h} = 10,800 \text{ s}$

Rearrange: $P = \Delta E/t$, so $\Delta E = Pt$

Substitute: $\Delta E = (9.0 \text{ J/s})(10,800 \text{ s}) = 97,200 \text{ J}$

Answer: $\Delta E = \mathbf{9.7 \times 10^4 \text{ J}}$

-
5. A 1,200 W electric kettle transfers 24,000 J of energy to the water. How long does this take?

Knowns: $P = 1,200 \text{ W}$, $\Delta E = 24,000 \text{ J}$, $t = ?$

Rearrange: $t = \Delta E / P$

Substitute: $t = 24,000 \text{ J} / 1,200 \text{ J/s}$

Answer: $t = 20. \text{ s}$

Part C: Putting It Together

6. An elevator motor lifts an 800. kg elevator car 15 m at a constant speed in 20. s.
- How much work does the motor do?
 - What is the motor's power in watts and in kilowatts?
 - What is the motor's power in horsepower (1 hp $\approx$ 746 W)?
- a.** Constant speed, so $W = mgh = (800. \text{ kg})(9.8 \text{ m/s}^2)(15 \text{ m}) = 117,600 \text{ J} \approx \mathbf{1.2 \times 10^5 \text{ J}}$
- b.** $P = W/t = 117,600 \text{ J} / 20. \text{ s} = 5,880 \text{ W} \approx \mathbf{5,900 \text{ W} = 5.9 \text{ kW}}$
- c.** $5,880 \text{ W} \times (1 \text{ hp} / 746 \text{ W}) = 7.88 \text{ hp} \approx \mathbf{7.9 \text{ hp}}$

-
7. Three students do work in the weight room. Complete the table, then answer the questions.

Student	Work (J)	Time (s)	Power (W)
Lena	1,800	6.0	300
Omar	2,400	12	200
Zoe	1,500	3.0	500

- Show your work for each missing value.
 - Omar did the most work. Does that make him the most powerful? Explain.
- a.** Lena: $P = 1,800 \text{ J} / 6.0 \text{ s} = \mathbf{300 \text{ W}}$ Omar: $t = W/P = 2,400 \text{ J} / 200 \text{ W} = \mathbf{12 \text{ s}}$ Zoe: $W = Pt = (500 \text{ W})(3.0 \text{ s}) = \mathbf{1,500 \text{ J}}$
- b. No.** Power is how fast work is done, not how much. Omar has the **least** power (200 W) because he took the longest. Zoe did the least work but is the most powerful (500 W) because she did it fastest.