

# P · Quantities and units in mechanics

AQA · A-Level · Mathematics

## Scope and prerequisites

AQA A-level Mathematics 7357, section P (Quantities and units in mechanics), version 1.3 (first assessment 2018). Original teaching notes.

Prerequisites: scientific notation and unit conversions from GCSE.

These are original teaching examples, not official AQA material.

## Quantities and units in mechanics

### ■ The question

- A report says a cyclist did “300 N of work pedalling 50 metres.” A marker crosses it out without checking any numbers. What did the marker see?
- Before reading on, say what is wrong with that sentence dimensionally, and what units work, force and power each need.

### ■ The method

- Every mechanics quantity is built from the base units kilogram, metre and second: velocity is m/s, acceleration is m/s<sup>2</sup>, force is the newton (kg m/s<sup>2</sup>), work is the joule (N m) and power is the watt (J/s).
- **Work** is energy transferred by a force through a displacement:  $W = Fs$  in the direction of the force. **Power** is the rate of doing work:  $P = W/t$ . Units are checked on every line – a correct equation gives the same unit on both sides, so a dimensional mismatch proves a slip before any number is trusted.
- work: Energy transferred by a force through a displacement,  $W = Fs$ , in joules;  
power: The rate of energy transfer,  $P = W/t$ , in watts.

Every mechanics quantity is built from kg, m and s



Check units on every line:  $W = Fs$  gives  $N \cdot m = J$ ,  
 $F = ma$  gives  $kg \times m/s^2 = N$

$$m \div s \rightarrow m s^{-1} \div s \rightarrow m s^{-2} \times kg \rightarrow N = kg m s^{-2}$$

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## ■ Checking your work

- Convert before combining: speeds in km/h must become m/s (divide by 3.6) before meeting forces or energies. A value's unit is part of its meaning; a bare number is not an answer in mechanics.
- Check a formula dimensionally on the DATA line, not just the result: if  $F = ma$  is to give newtons,  $m$  must be in kilograms and  $a$  in  $\text{m/s}^2$ .

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## ■ A worked case

- Known: a cyclist applies 80 N over 50 m in 20 s.  $\text{Work} = Fs = 80 \times 50 = 4,000 \text{ J}$ .  $\text{Power} = W/t = 4,000/20 = 200 \text{ W}$ . The “300 N of work” sentence fails dimensionally: newtons are force, and work is measured in joules.

### Example:

A 60 kg student climbs 4 m of stairs in 10 s. Using  $g = 9.8 \text{ m/s}^2$ , find the work against gravity and the average power, using the same sequence: known  $\rightarrow W = mgh \rightarrow P = W/t$ . (Answer:  $W = 60 \times 9.8 \times 4 = 2,352 \text{ J}$ ;  $P = 2,352/10 \approx 235 \text{ W}$ .)

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## ■ Limits and traps

- A dimensional check catches wrong formulas but cannot catch a wrong NUMBER inside a right-shaped formula; units pass, then arithmetic must still be verified. “Powerful” is not a technical term – compare watts, not adjectives.

### Warn:

Work, force and power can be quoted in the same units because they all involve force. This claim is false: force is in newtons, work in joules ( $\text{N} \cdot \text{m}$ ) and power in watts ( $\text{J/s}$ ) – different dimensions, and confusing them produces nonsense like “300 N of work.”

### Key:

Quantities and units in mechanics: everything builds from kg, m, s; work is  $W = Fs$  in joules, power is  $W/t$  in watts, and a dimensional check on every line catches formula slips before the arithmetic is trusted.