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^2, force is the newton (kg m/s^2), 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·m = J,
F = ma gives kg × m/s² = N

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

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 m/s^2.

A worked case

- Known: a cyclist applies 80 N over 50 m in 20 s. Work = Fs = 80 × 50 = 4,000 J. Power = W/t = 4,000/20 = 200 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 m/s^2, find the work against gravity and the average power, using the same sequence: known → W = mgh → P = W/t. (Answer: W = 60 × 9.8 × 4 = 2,352 J; P = 2,352/10 ≈ 235 W.)

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 (N · m) and power in watts (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.