

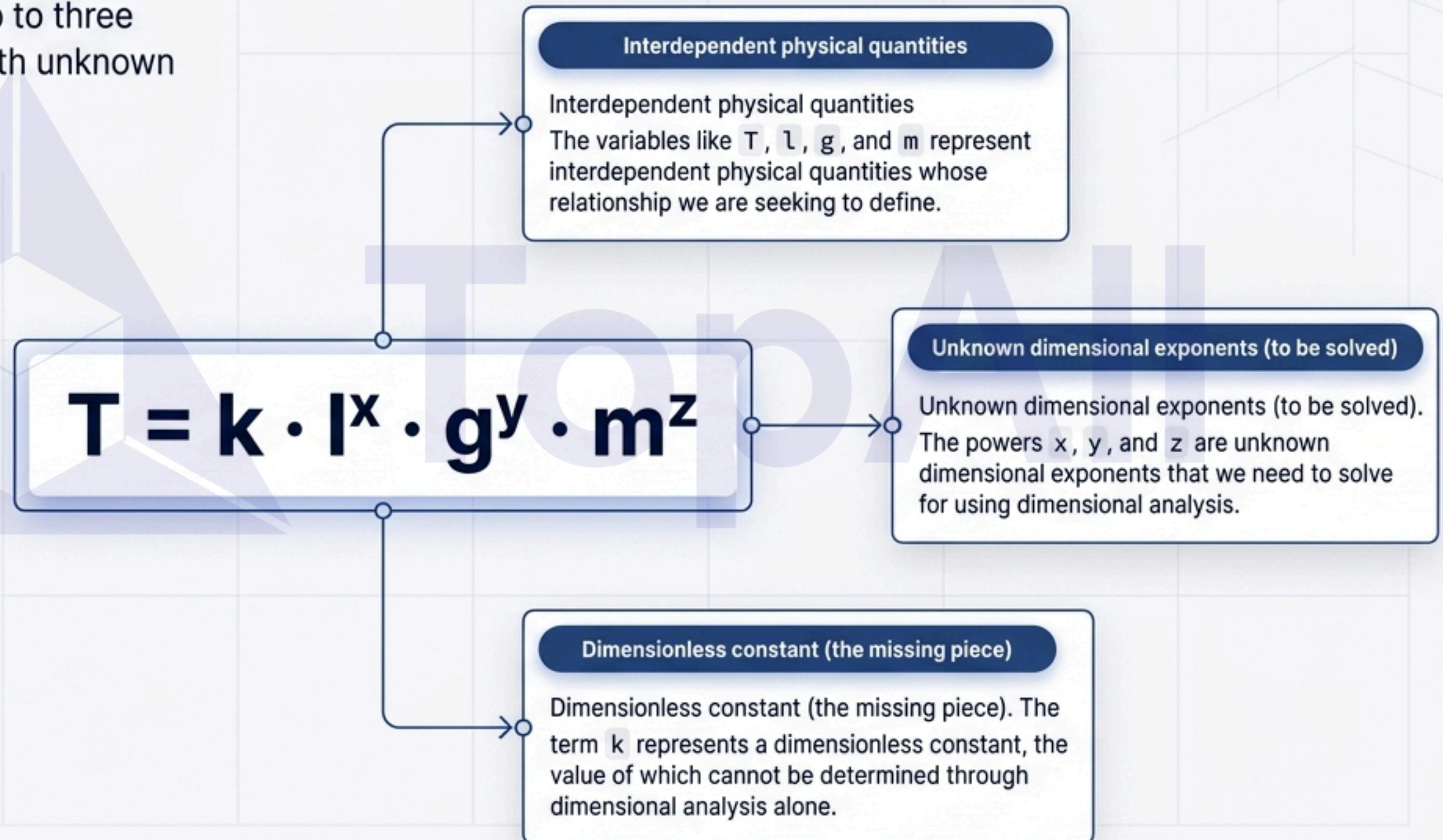
Units and Measurement · Concept 9

Deducing Relations Among Physical Quantities

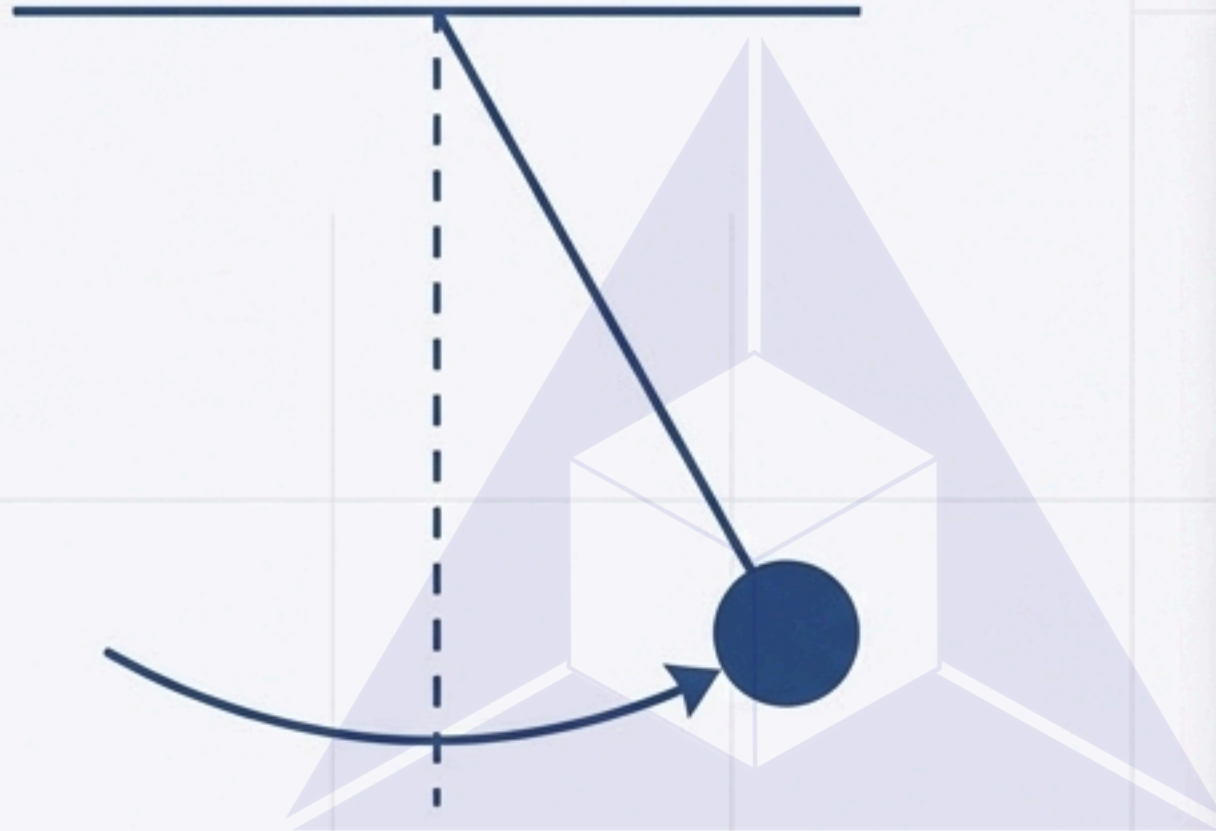
Using dimensional analysis to construct the blueprint of a physical formula.

The Product-Type Assumption

To deduce a relationship, we assume the physical quantity depends on up to three variables, linked as a product with unknown dimensional exponents.



Case Study: The Simple Pendulum



Suppose the period of oscillation depends on its length, the mass of the bob, and gravity.

Target Quantity: Time Period T

→ Dimensions: $[T]$

Variable 1: Length of string ℓ

→ Dimensions: $[L]$

Variable 2: Acceleration due to gravity g

→ Dimensions: $[LT^{-2}]$

Variable 3: Mass of the bob m

→ Dimensions: $[M]$

Equate dimensions on both sides of our assumed product based on the principle of homogeneity.



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$$E=mc^2$$



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Derivation Step-by-Step

Step 1: Setup

$$[L^0 M^0 T^1] = [L]^x [LT^{-2}]^y [M]^z$$



Step 2: Combine

$$[L^0 M^0 T^1] = [L]^{x+y} [T]^{-2y} [M]^z$$



Step 3: Equate Exponents

$$x + y = 0$$

$$-2y = 1$$

$$z = 0$$



Step 4: Solve

$$x = 1/2, y = -1/2, z = 0$$



Result

$$T = k \cdot l^{1/2} \cdot g^{-1/2} \rightarrow T = k\sqrt{l/g}$$

The Final Equation

$$T = 2\pi\sqrt{l/g}$$

Obtained experimentally or theoretically—this value cannot be deduced through dimensional analysis alone.



TRAP ALERT

Dimensional analysis gives the exponents — never the dimensionless constant **k** — and cannot distinguish between same-dimension quantities.

If a dimensionally consistent equation fails the test, it is proved wrong. But if it passes, it is not guaranteed to be the exact physical relationship.



Key Takeaways

The method of dimensions builds a relation's form from up to three variables; the numerical constant always comes from elsewhere.



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