



Formulas & Relationships

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DEFINITIONS:

Direct Proportions: Two quantities related in such a way that they vary directly by a given factor. If you double one quantity the other also doubles; or if you take one half of one quantity the other is also half as much.

Inverse Relationship: Two quantities related in such a way that they vary by inverse factors. If you double one quantity the other is half as much; or if you take one half of one quantity the other is doubled.

Squared Relationship: A quantity varies by a square factor of another quantity. If you double the quantity that is squared the other quantity is four times as much; or if you take one half the quantity that is squared the other quantity is one fourth times as much.

Inverse Squared Relationship: A quantity varies by an inverse square factor of another quantity. If you double the quantity that is squared the other quantity is one fourth as much; or if you take one half of the quantity that is squared the other quantity is four times as much.

Sample Formulas

Ideal Gas Law

$$PV = nRT$$

Newton's Second Law

$$F = ma$$

Kepler's Third Law

$$m = \frac{a^3}{T^2}$$

Distance Fallen in Free Fall

$$d = \frac{1}{2}gt^2$$

Frequency & Wavelength

$$c = f\lambda$$

Universal Law of Gravitation

$$F = G \frac{m_1 m_2}{R^2}$$

EXERCISES:

- List two examples from the list of formulas that illustrate direct proportion, and state the quantities that are directly proportional if other quantities are constant.
- List a formula that illustrates an inverse relationship and state the quantities that are inversely related if the other quantities are constant.
- What is the relationship between d and t in the formula $d = \frac{1}{2}gt^2$?
- Which formula illustrates an inverse square relationship?
- Solve the following equations below for the variable that is specified.
 - $c = f\lambda$ solve for λ
 - $F = G \frac{m_1 m_2}{R^2}$ solve for m_2
 - $d = \frac{1}{2}gt^2$ solve for t
- Evaluate the formula $F = G \frac{m_1 m_2}{R^2}$ to find F given:
$$G = 6.67 \times 10^{-11} \text{Nm}^2/\text{kg}^2, \quad m_1 = 5.97 \times 10^{24} \text{kg},$$
$$m_2 = 1.99 \times 10^{30} \text{kg}, \quad \text{and} \quad R = 1.5 \times 10^{11} \text{m}$$
- For problem 6 above, what will happen to F if R is doubled? (Choose)
 - F is twice as much
 - F is halve as much
 - F is 4 times as much
 - F is one quarter as much

Answer Key:

1. For $PV = nRT$: $P \propto n$ or $P \propto T$; For $F = ma$: $F \propto a$;
For $F = G \frac{m_1 m_2}{R^2}$: $F \propto m_1$ or $F \propto m_2$
2. For $F = ma$: $m \propto a$; For $c = f\lambda$ $f \propto \lambda$
3. Squared relationship
4. $m = \frac{a^3}{T^2}$ between m and T or $F = G \frac{m_1 m_2}{R^2}$ between F and R
5. i) $\lambda = \frac{c}{f}$ ii) $m_2 = \frac{FR^2}{Gm_1}$ iii) $t = \sqrt{\frac{2d}{g}}$
6. $F = 3.5 \times 10^{22}$ N
7. "d" F is one quarter as much