Patterns and Relationships in Physics

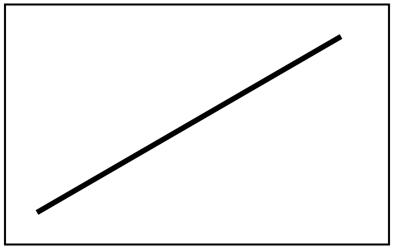
Honors Physics

Direct and Inverse Relationships

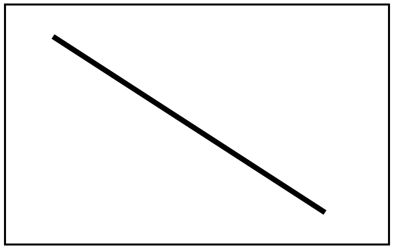
If you are going to understand science or physics in general you MUST understand that physics is basically all about RELATIONSHIPS and how things change.

In ALL the science there are basically TWO types of relationships:

Direct - This is where the two variables do the SAME THING. That is, if one increases so does the other and vice versa.



Inverse - This is where the two variables do the OPPOSITE. If one variable increases, the other variable decreases.



Directly "proportional"

RELATIONSHIPS are usually written as proportionalities and use the Greek letter, ALPHA α, to symbolize the proportion. To make an equation we add a constant and change the proportionality sign into an equals sign.

Direct

$A \alpha B$

$A = kB$

k = Constant of Proportionality

Direct relationship example:

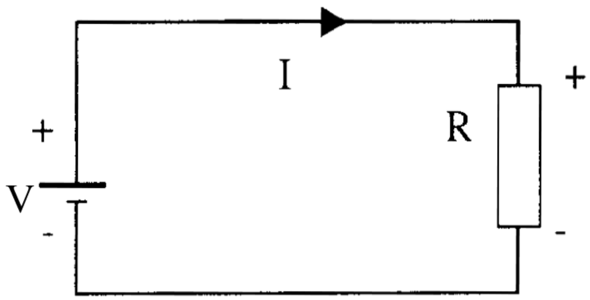
$A = kB$

$\text{cost}(\$) = (\text{price per pound})(\text{weight})$

If the weight goes up, so does the cost and vice versa.

What two things change (A & B)? Cost and weight
What is the constant (k)? Price per pound

Physics Example



Ohm's Law : V = RI . Voltage (V) is directly related to the current (I) when the resistance (R) is constant.

$$A = kB$$
$$V = RI$$

Newton's 2nd Law: F_{net} = ma. The acceleration is directly proportional to the NET force if the MASS is constant.

$$A = kB$$
$$F_{net} = ma$$

Inversely “proportional”

Inverse

$$A \,\alpha\, \frac{1}{B}$$

$$A = \frac{k}{B}$$

$$k = \text{Constant of Proportionality}$$

Inverse relationship example:
(/ = divided by)

Output of cars = Constant / production time per car - If the time per car DECREASES, you are able to INCREASE the number of cars you get.

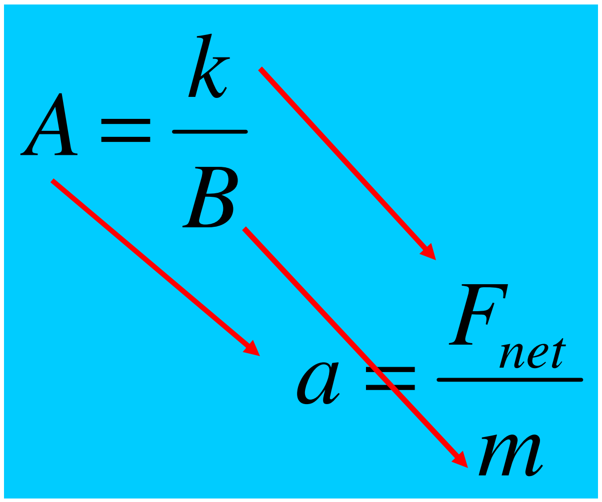
$$A = \frac{k}{B}$$

$$\text{Output of cars} = \frac{\#\text{ of workers}}{\text{time to make 1 car}}$$

What two things change? Output of cars and the time it takes to make each car
What is the constant? The number of workers (they simply have to work faster)

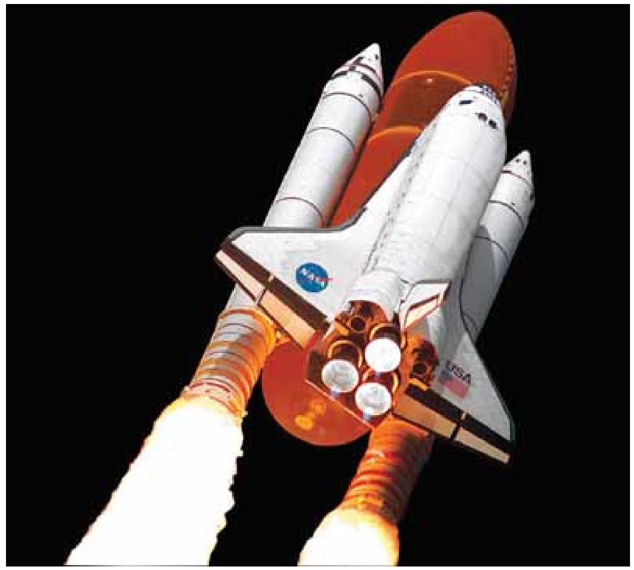
Physics Example

Newton's Second Law: $a = F_{net} /m$. The acceleration is inversely proportional to the mass if the FORCE is constant.



$$A = \frac{k}{B}$$

$$a = \frac{F_{net}}{m}$$



A good example is the space shuttle, as the shuttle loses fuel and jettisons it’s solid rocket boosters it therefore loses mass. If the mass DECREASES, the acceleration INCREASES provided the FORCE (of thrust) remains constant.

Other types of relationships

Direct Square

$$A = kB^2$$

Inverse Square

$$A = \frac{k}{B^2}$$

These kinds of relationships can be a bit tricky for physics students to understand. Basically if B "DOUBLES" then A "QUADRUPLES", due to the square. If B "triples" then A increases by NINE.

For the inverse square" if B "DOUBLES", then A DECREASES by a factor of FOUR, or it is simply ONE FOURTH its original value. If B "TRIPLES", then A is ONE NINTH its original value.

Physics Examples

$$A = kB^2$$

$$KE = \frac{1}{2}mv^2$$

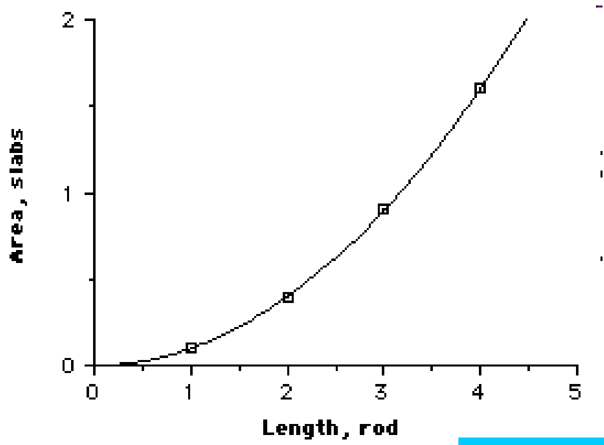
In the case of kinetic energy, we see that the kinetic energy is DIRECTLY related to the "square" of the velocity, when the mass is constant.

$$A = \frac{k}{B^2}$$

$$F_g = \frac{GMm}{r^2}$$

In the case of Newton's Law of Gravitation, we see that if the force due to gravity DECREASES, the distance from Earth, r, must have INCREASED by a square factor.

Physics graphs to look for



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