Newton's First Law

An object
will remain at rest

or in uniform motion

unless an unbalanced force acts upon it.

Seems obvious but deserves a little analysis.

For example these beer bottles have the force of gravity pulling them down but they don't move because the table top is pushing up at the same time, with an exactly equal and opposite force. The overall force is zero.

Table pushes back up

Even though this truck is being pushed hard, it is not moving because friction is acting. The forces are balanced.

The freewheeling cyclist will only stop if friction brings her to a halt, which, on Earth, it always will.

An astronaut or any other object in deep space, a long way from any large masses and gravitational fields will experience no forces. Once moving the object will move at the same speed for ever, unless another force comes in to play.

However if an unbalanced force acts, as with this rocket where the thrust of the rocket is far greater than friction,, the object accelerates.

This leads on to Newton's Second Law.

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Newton's Second Law states that:
The acceleration of an object is in the same direction as the force applied and is directly proportional to the size of the force.

We can see that the larger the force then the larger the acceleration. So the Sinclair C5 electric car does not accelerate as fast as the dragsters. In mathematical terms that is
Force $\propto$ acceleration

or $F \propto a$

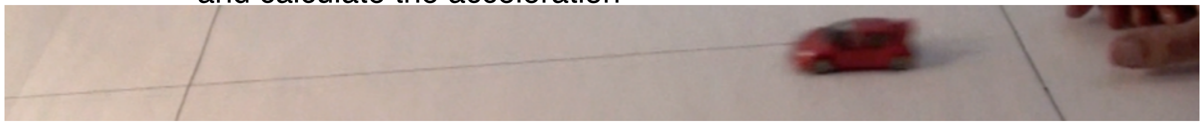
but we also know that if the mass is large then it is hard to accelerate,

so the rickshaw on the right may be rather hard to get going.

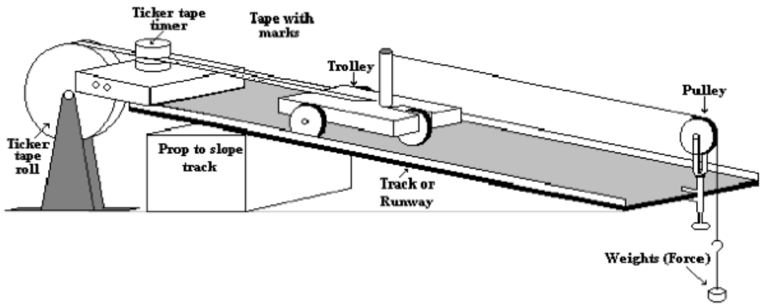
Mass is the constant of proportionality. The equation becomes:
$F = m \times a$

To test the law we can accelerate a mass with a variety of constant forces on a very low friction surface

and then time it between two marks and calculate the acceleration



or use a ticker-timer to measure the changing velocity



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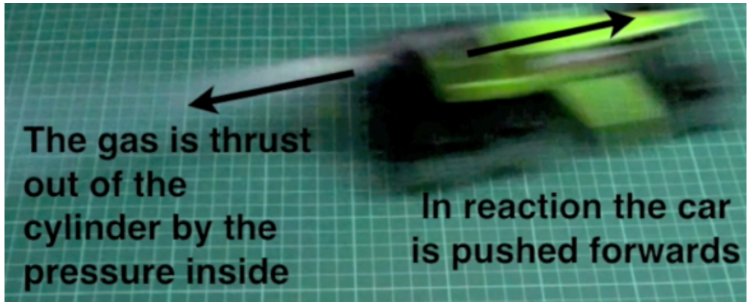
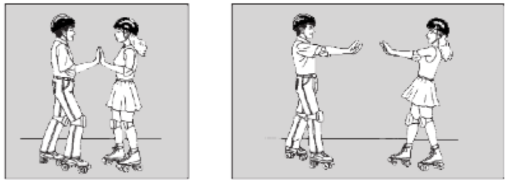
Newton's Third Law states that:

For every action there is an equal and opposite reaction:

The bullet fires out and the gun kicks back.





skaters push each other apart, both move backwards.

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From this we derive the idea of impulse and **the Law of Momentum.**

Take the example of the skaters. The force on one is the same as the force on the other and they push against each other for exactly the same amount of time, so

F x t is the same for each (although in opposite directions).
The term F x t is called the impulse.

Now from the second law F = m x a
and acceleration = change in velocity/ time i.e. $a = \frac{v}{t}$

so $F = \frac{mv}{t}$ or rearranging **F x t = m x v** a very useful expression
The term mass x velocity is called the momentum.

the boy and girl are not the same size and are not likely to move back with the same velocity. If the boy has a mass M and velocity V
and the girl mass m and velocity v

because the boy and girl and pushing against each other with the same force for the same time:

F x t = M x V = m x v in size (but not direction).

The total momentum of the two before they pushed was zero, because they were not moving. After they pushed apart mv and MV are equal but opposite, so they cancel each other out.

This gives rise to the Law of Momentum that:

The change of momentum in a collision (or an explosion) is zero. The total momentum in any closed system is constant.