

Newton's Second Law

$$\Sigma F = ma$$

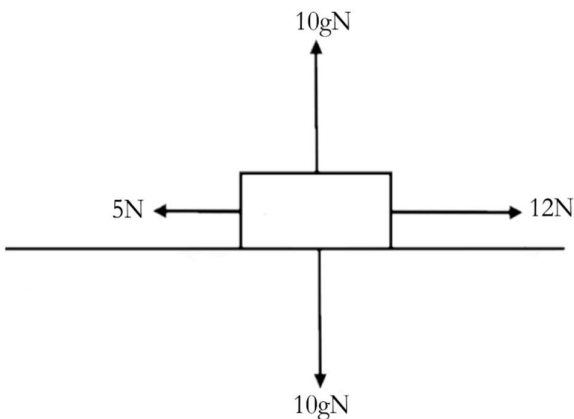
This equation is used in many areas of classical mechanics, and it means (resultant force) = (mass) \times (acceleration). We write ΣF to represent resultant force as often there can be more than one force acting on an object, so we use sigma (Σ) as it represents the sum of all of these forces. The equation is usually used under the assumption that mass remains constant – mass stays the same. Note that force and acceleration are both vectors¹ so the direction of the resultant force will be the same as the direction of the acceleration.

For example, a horizontal force of 12N (12 Newtons) pulls a box along a rough surface. The frictional force is 5N. The mass of the box is 10kg. Find its acceleration.

Firstly, we should draw a diagram. This will give us a better understanding of what is going on.

There are two horizontal forces that are acting on the box, the pulling force and the frictional force. The box is being moved in the direction of the pulling force, and friction acts in the opposite direction to motion.

There are also two vertical forces acting on the box, weight and the normal reaction². Because the box is neither accelerating upwards nor accelerating downwards, these forces must be equal to each other. (Weight) = (mass) \times (gravitational field strength), gravitational field strength gives us the acceleration due to gravity. This makes sense because $F = ma$. Weight is a force, mass is mass and g.f.s.³ is acceleration. $G.f.s. = 9.8^4$, but is often written as g. So $10gN = 98N$.



The resultant force acting on the box is $12 - 5 = 7N$ to the right, so $7 = 10a$ so $a = 0.7ms^{-2}$

Proof

The only way to “prove” such an equation is by experimental observation. This equation is often used in mechanics, rather than pure mathematics and so cannot be derived.

See also

- Friction Equation

References

Attwood, G. et al. (2017). *Edexcel AS and A level Mathematics - Statistics and Mechanics - Year 1*. London: Pearson Education. p.162.

¹ This means that they are quantities with both magnitude and direction, whereas mass only has magnitude

² The normal reaction is the force the ground exerts on the box, so that it does not fall through the floor

³ Gravitational field strength

⁴ The unit for g.f.s. is N/kg or Nkg^{-1} or m/s^2 or ms^{-2} , remember that a negative power of a value means the reciprocal of the positive power of a value, so $s^{-2} = \frac{1}{s^2}$, so $ms^{-2} = m/s^2$, the same is true for N/kg and Nkg^{-1}

