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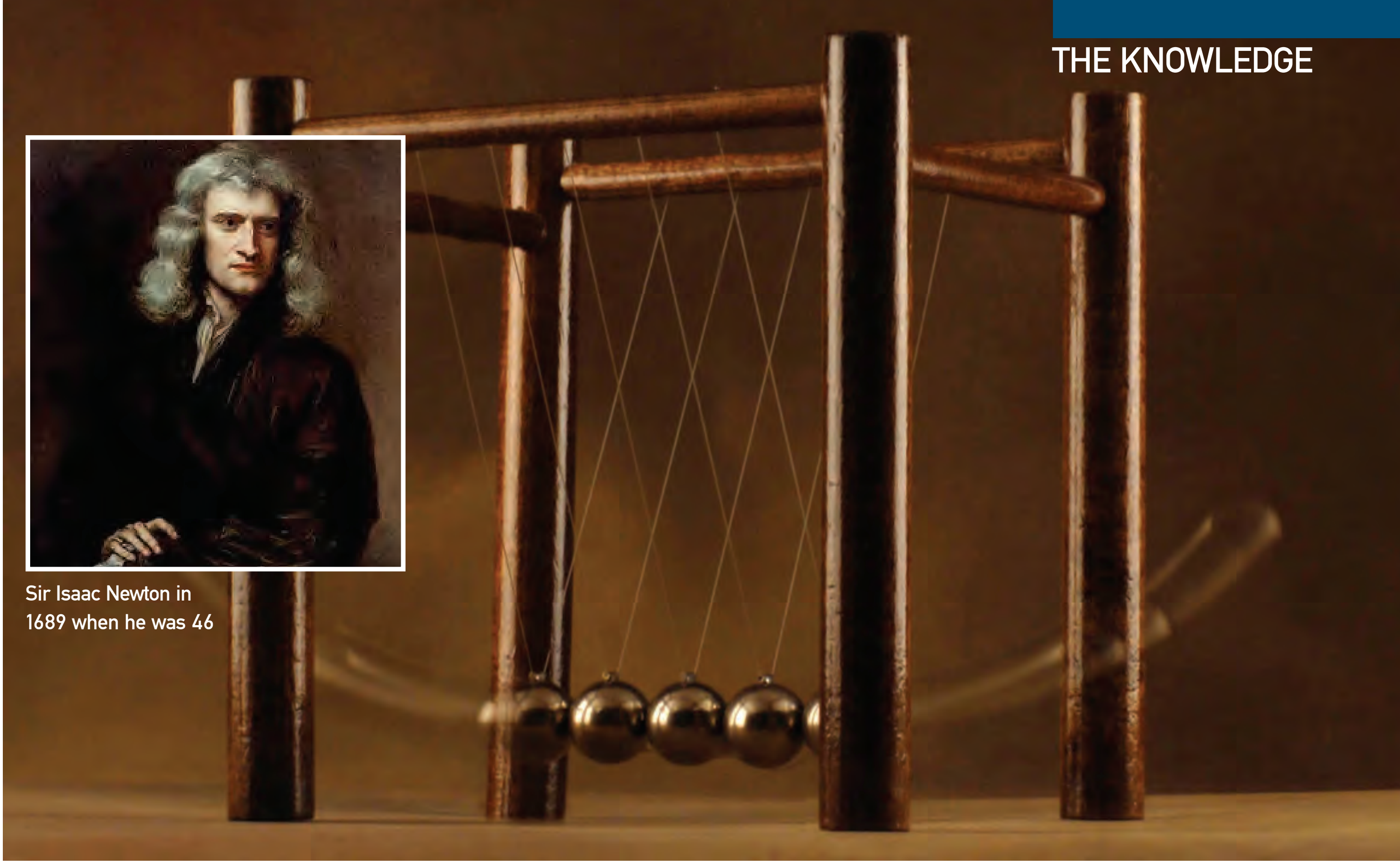

Sir Isaac Newton in 1689 when he was 46

Introducing know-how

The first in a new series of practical how-to articles aimed at improving safety in heavy transport and lifting operations. We are excited to announce that MARCO VAN DAAL will regularly contribute his extensive industry knowledge for the benefit of all readers

ABOUT THE AUTHOR

Marco J. van Daal has been in the heavy lift and transport industry since 1993. He started at Mammoet Transport from the Netherlands and later with Fagioli PSC from Italy, both esteemed companies and leading authorities in the industry. His 20-year plus experience extends to five continents and more than 55 countries.

It has resulted in a book *The Art of Heavy Transport*, available at: www.the-works-int.com

Van Daal has a real passion for sharing knowledge and experience, the prime reason, he says, for the seminars he holds all over the world. He lives in Aruba, Dutch Caribbean, with his wife and two daughters.

Welcome to the first in a series of articles in which a number of topics related to the heavy lift and transport industry are highlighted, explained and demystified. The main reason for writing these articles is that I believe a good explanation of a theory or topic, or just a situation that one ran into, is more valuable than somebody showing you how to do something without telling you why it is done that way.

Although our industry has moved, shipped, lifted and transported some of the most amazing cargo of unimaginable sizes and unthinkable weights, there are a few very basic laws of nature that these moves abide by. A thorough understanding of these laws of nature will aid in proper equipment selection, recognition of the forces and a timely identification of unwanted situations.

Believe it or not, there are still too many accidents that result in equipment damage and injury or loss of life. This first article will, therefore, not cover heavy transport or lifting. Instead it goes back in history and touches on these laws of nature and who discovered them. I realise that not everybody is an avid reader of history but I assure you that it will help you understand the future articles much better with this theory "in your pocket."

Isaac Newton

Sir Isaac Newton (25 December 1642 – 20 March 1727), an English physicist and mathematician, is by many regarded as the greatest genius who ever lived. He contributed to science in different fields, including the laws of planetary motion, speed of sound, light spectrum and the binomial theorem (for the mathematically gifted amongst us). He is, however, best known for the contents of his book, *Principia Mathematica* (1687), in which he explains three physical laws that form the basis for classical mechanics. These laws are now known as Newton's laws of motion.

NEWTON'S FIRST LAW

Newton's first law says that if there is no resulting force on an object, then its velocity is constant. The object is either at rest (velocity of zero), or it moves with a

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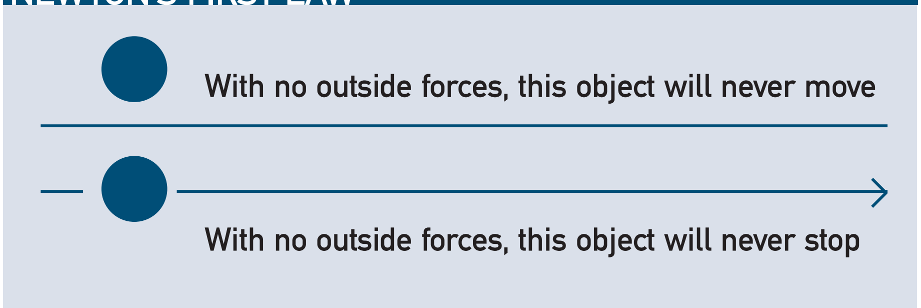
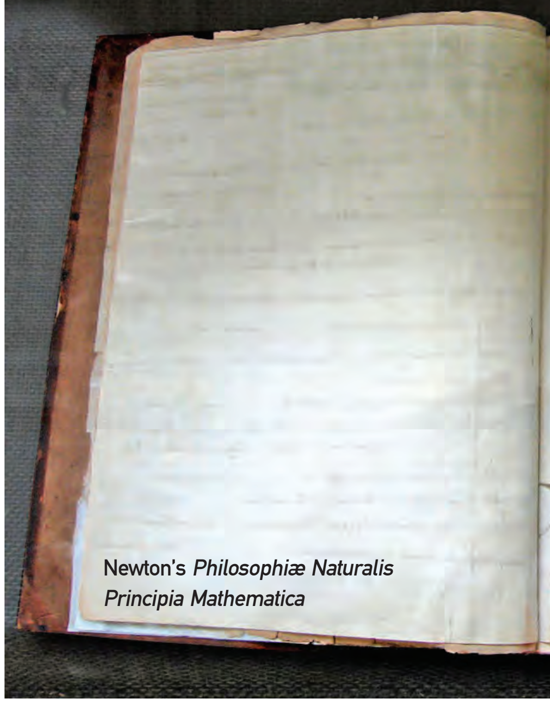
NEWTON'S FIRST LAW




Newton's *Philosophiæ Naturalis Principia Mathematica*

constant speed in a straight direction.

This first law basically states that an object is in rest (zero velocity) if there is no external force applied to it, this is the easy part. This law also states that if no resulting force is applied to an object it could as well be moving at a constant speed in a straight direction, this is a bit harder to fathom. Imagine a hockey puck that is struck and slides down an asphalt surface. Due to the friction, a resulting force, between the puck and the asphalt, the puck eventually stops sliding. Now let's assume that this same puck is struck and it slides down an ice track. The distance the puck travels is a lot further than on asphalt because the friction, a resulting force, between the puck and ice is much less. If the ice could be so smooth that the friction would be zero, then this puck would keep travelling in a straight line with a constant velocity and never stop.

How is this applicable in our industry? A frequently used method of moving loads is skidding. In its simplest form, skidding is the overcoming of friction by applying a resulting force, often in the shape of an hydraulic pushing ram, on a friction-reducing material such as Teflon (PTFE) on stainless steel. The lower the friction between these two materials, the lower the effort can be to move the object. Once the hydraulic ram stops pushing (at the end of the stroke), once again the friction force is the resulting force and will return the object to a state of "at rest". If there would be no friction between the Teflon and the stainless steel, the object would keep moving at a constant speed at the end of the stroke. Obviously an unwanted situation. Even though we want the friction to be as low as possible, we still rely on it being present at the end of the stroke.

NEWTON'S SECOND LAW

If there is a resulting force on an object it will accelerate. The acceleration is in the direction of the resulting force and is directly proportional to it, and it is inversely proportional to the mass of the object.

This law is an extension of the first law. It basically states that if the resulting force on an object doubles, then the acceleration also doubles, this is directly proportional. If the mass of an object doubles while applying the same resulting force, then the acceleration halves, this is inversely proportional. The relation between the resulting force, the acceleration and the object's mass can be expressed in a formula: $F = m \times g$ where F is the force expressed in Newtons, m is the mass expressed in kg and g is the acceleration expressed in m/s^2.

How is this applicable in our industry? We know from Newton's first law that without a resulting force the object would keep sliding on the Teflon and stainless steel skid track.

Newton's second law states, however, that when a resulting force is applied, the friction force, an acceleration, takes place. Since the object slows down, the acceleration has a negative value and is also called a deceleration.

Another application of Newton's second law is when a driver decides to apply his brakes, which is considered another resulting force, he would come to a standstill. If he pushed the brakes twice as hard, the acceleration will double, due to $F = m \times g$ and he will stop twice as fast.

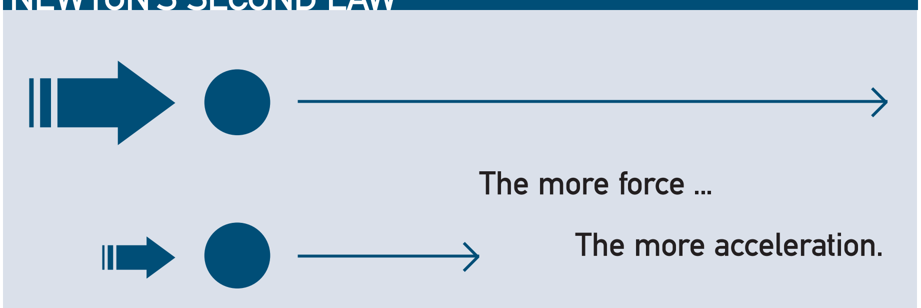
NEWTON'S THIRD LAW

When an object exerts a force, F1, on a second object, the second object simultaneously exerts a force F2 = −F1 on the first body. The forces F1 and F2 are equal in magnitude and opposite in direction. This law is also known as "action = −reaction" and has often been a law of controversy.

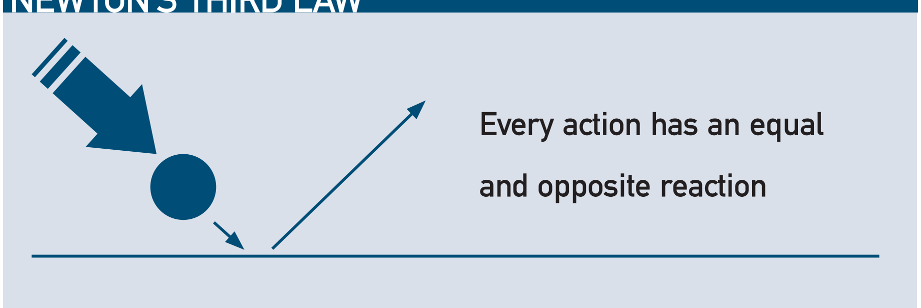
Imagine that you are pulling on a rope that is attached to a wall, you pull with 110 pounds (50 kg). Actually you pull with a force of approximately 500 Newton.

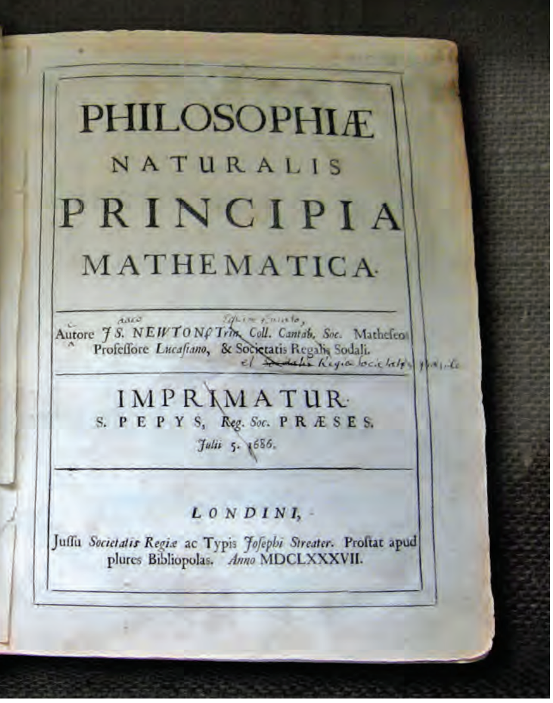
Now replace the wall by a person who pulls on the other end of the rope. The controversy has been in the belief that if each person pulls with 250 N there will

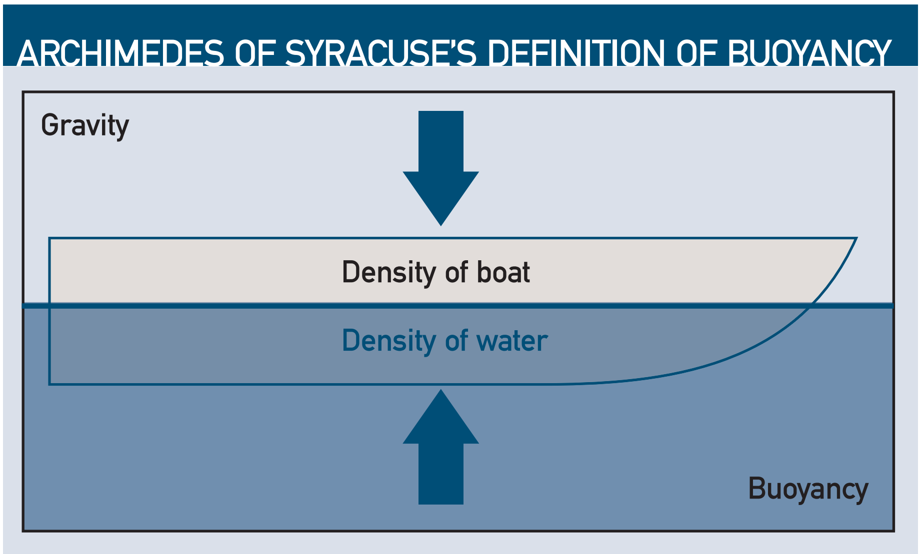
NEWTON'S SECOND LAW



NEWTON'S THIRD LAW







be a tension of 500 N in the rope. Newton has put an end to this belief with his third "action = –reaction" law. To create a tension of 500 N in the rope, both people have to pull with a force of 500 N in opposite directions.

How is this applicable in our industry? When a load is suspended from a crane hook, this load exerts a force onto the boom tip of that crane. At the same time the boom tip (via hydraulic cylinders and/or pendant ropes) exerts the same force onto the load that prevents it from falling down. Assuming that the load measures 500 N, then this is the force exerted onto the boom as well as onto the load.

Archimedes of Syracuse

Widely known as just Archimedes, Archimedes of Syracuse (287 – 212 BC) was a Greek mathematician, physicist, engineer, inventor and astronomer. He left us with the principle of the lever, a crane in its most basic form. He is also credited with the foundations of hydrostatics. In particular, buoyancy is important in our industry for ships and barges. For every voyage, lift-on, lift-off, roll-on and roll-off, the buoyancy is monitored as it keeps the ship or barge afloat.

Buoyancy is defined as the upward force exerted on a submerged object, by the liquid it is submerged in, equal to the weight of the liquid that the object displaced.

According to Newton's third law, there should be another (downward) force at play as "action = –reaction". This is indeed the case, the other force is the gravitational force, the buoyancy and gravitational forces are equal in magnitude and opposite in direction.

With these three laws of Newton and the hydrostatic and buoyancy laws of Archimedes under your belt, you are able to understand the forces that play on an object being transported or lifted by land or sea or both. ■

Archimedes is credited with the principle of the lever – a crane in its most basic form