# The Physics of Energy

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# I Introduction to Energy

## Luca Gammaitoni
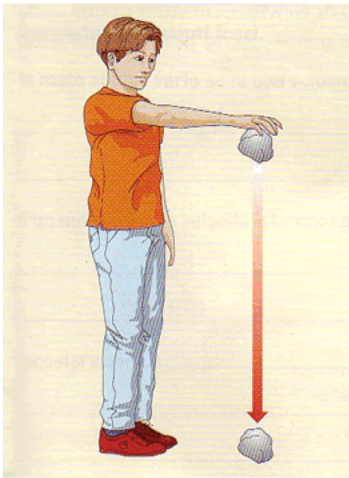
The Physics of Energy

# Energy



# What is it?

# Energy

In physics, energy (Ancient Greek: ἐνέργεια energeia "activity, operation")
is an indirectly observed quantity that is often understood as the
**ability of a physical system to do work on other physical systems**
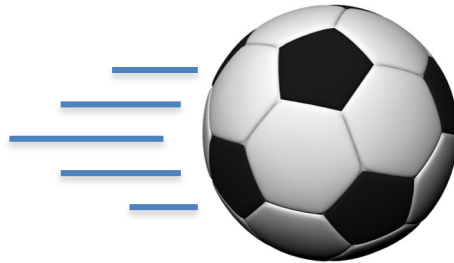
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Energy ?                Energy ?                Energy ?

# Energy



"*It is important to realize that in physics today, we have no knowledge what energy is.*"

Richard Feynman, in The Feynman Lectures on Physics (1964) Volume I, 4-1

# Energy: a hint of history

The *vis viva* (living force), which **Gottfried Leibniz** defined as the product of the mass of an object and its velocity squared; he believed that total vis viva was conserved.



To account for slowing due to friction, Leibniz theorized that thermal energy consisted of **the random motion of the constituent parts of matter**, a view shared by **Isaac Newton**, although it would be more than a century until this was generally accepted.

# Energy: a hint of history

The **conservation of energy** was proposed by [Gottfried Leibniz](#) over the period 1676–1689, the theory was controversial as it seemed to oppose the theory of [conservation of momentum](#) advocated by Sir [Isaac Newton](#) and [René Descartes](#). The two theories are now understood to be complementary.

In 1807, **Thomas Young** was possibly the first to use the term "energy" instead of vis viva, in its modern sense.
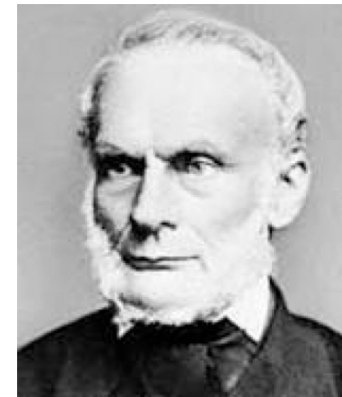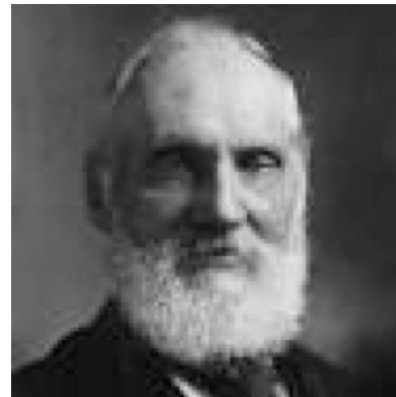
# Energy: a hint of history

**Gustave-Gaspard Coriolis** described "kinetic energy" in 1829 in its modern sense.

In 1853, **William Rankine** coined the term "potential energy".

William Thomson (Lord **Kelvin**) amalgamated all of these laws into the laws of thermodynamics, which aided in the rapid development of explanations of chemical processes by

**Rudolf Clausius**, **Josiah Willard Gibbs**, and **Walther Nernst**.

# Energy: a hint of history

It also led to a mathematical formulation of the concept of entropy by Clausius and to the introduction of laws of radiant energy by **Jožef Stefan**.
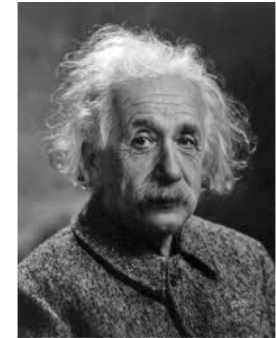




**Albert Einstein** proposed mass–energy equivalence in 1905 in a paper entitled "Does the inertia of a body depend upon its energy-content?".

Since 1918 it has been known that the law of conservation of energy is the direct mathematical consequence of the translational symmetry of the quantity conjugate to energy, namely time (**Emmy Noether**).