

Energy is the ability to perform a work, and it's measured in **joules** (1 J =Mechanical, kinetic and potential energy

Kinetic energy KE

It's the energy of a body due to its **motion**. It depends on the mass *m* and

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

Potential energy PE

It's the energy contained on a body due to its position and/or configurate Gravitational potential energy of a mass m at a height h over the Earth calculated as:

$$PE_g = mgh,$$

where $h \ll R_{\rm E}$ (being $R_{\rm E}$ the Earth's radius) and g is the value of gravity's a

Mechanical Energy $E_{\rm m}$

It's the addition of the kinetic energy, KE, plus the potential energy, $E_{\rm m} = {\rm KE} + {\rm PE}$

Conservation of energy

Conservation mechanical energy

When only **conservative forces** are acting on a body, its mechanical en constant.

Examples of conservative forces are: gravitational, elastic or electrostati Friction is an example of a non-conservative or dissipating force.

Conservation of energy

In any nature's process, the **total** energy remains constant.

Energy transfer

Energy can be transferred/exchanged due to **work** or **heat**.

Work W

Work is transferred when one body exert over another body forces that p ments or changes in their dimensions.

The work W done by a constant force \vec{F} can be calculated as:

 $W = \vec{F} \cdot \vec{d} = F \cdot d \cdot \cos \alpha,$

where F is the value of the applied force, d is the displacement and $\cos \alpha$ is angle formed by the force and the displacement.

Heat Q

Heat is transferred between two bodies at a different temperature. The a body at a higher temperature is equal to the heat absorbed by the body at ature: $Q_{\text{released}} + Q_{\text{absorbed}} = 0.$

For historical reasons, heat is often measured in **calories** (1 cal = 4.19 J).

ENERGY, WORKAND HEAT

15-16 year-olds

Rodrigo Alcaraz de la Osa. Translation: Rodrigo Alcaraz de la Osa and Alicia Sampedro (🗩 @AliciaInfoFyQ)

$= 1 \text{ kg m}^2 \text{ s}^{-2}$).		ork and Powe
	Power <i>P</i> is defined as the work <i>W</i> do	one by unit of time
	P =	$\frac{W}{t} = \frac{\vec{F} \cdot \vec{d}}{t} = \vec{F} \cdot$
d the velocity <i>v</i> :	In the SI power is measured in wat 735 W) another typical unit.	ts (1W = 1J/s),
	The kilowatt hour , kW h, is a unit c	of energy widely ι
	$1 \text{ kWK} \cdot \frac{1000 \text{ W}}{1 \text{ kW}} \cdot \frac{3}{2}$	$\frac{600 \text{ s}}{11} = 3.6 \times 10^6$
ition.		
n's surface can be		effects on bog
acceleration.	Change of temperature	
	The relationship between the heat Q in temperature ΔT of that mass is give	provided to a mas en by the equation
, PE:		$Q=m\cdot c\cdot \Delta T,$
	where <i>c</i> is the specific heat of that substance, which repshould be provided to the unit of mass of that substant unit. In the SI it is measured in $J kg^{-1} K^{-1}$.	
	Expansion	
	Usually, a body increases its volume (a	<i>it expands</i>) when in
<i>ergy remains</i> If we take a bar with an initial length l_0 at ature until T , the bar will increase its len proportional to the initial length l_0 and the		l ₀ at an initial temp length until <i>l</i> . T nd the change in te
ic forces.		
	$\Delta l = \alpha \cdot l_0 \cdot \Delta T,$	
	where α is the linear expansion co demonstrated that the area expansion are the double and the triple of the lin	efficient, whose and coefficient and the near one:
	$\Delta S = 2\alpha \cdot S_0$	$_{0}\cdot\Delta T;$ $\Delta V=3a$
produce displace-	Change of state	
	When heat is transferred to a body, its temperature incre a body changes, it can change its state of aggregation.	
the cosine of the	During a change of state, the temperature of the boo ergy transferred to the body is used in rearranging its pa	
	The amount of heat <i>Q</i> needed to change the state of a su and its mass <i>m</i> , through the equation:	
e heat released by .t a lower temper-		$Q = m \cdot L$,
	where <i>L</i> is the latent heat , which repr to change its state. In the SI it is meas	resents the amount sured in J/kg.

e *t*:

$$\vec{v}$$

being the **horsepower** $(1 \text{ CV} \approx$

used in electrical bills:

 $^{\circ}Ws = 3.6 \times 10^{6} \text{ J}$

dies

A heat engine is a system that works periodically between two foci at a different temperature, transforming part of the heat absorbed from the hot source in work and releasing the other part to the cold sink.



iss m of a substance and the change

epresents the amount of energy that nce to increase its temperature one

its temperature increases.

perature T_0 and we raise its temper-This length increase, $\Delta l = l - l_0$, is emperature $\Delta T = T - T_0$:



units in the **SI** are K^{-1} . It can be he volumetric expansion coefficient

 $\alpha \cdot V_0 \cdot \Delta T$

eases. But when the temperature of

dy remains **constant**, since the enarticles (breaking bonds).

ubstance depends on the substance

nt of energy needed by the substance

the cold sink T_2 , producing work: $Q_1 = W + |Q_2|$. Adapted from https://commons.wikimedia.org/wiki/File:Carnot_heat_engine_2.svg.

Thermal efficiency

The **thermal efficiency**, η , is defined as the quotient between *benefit* and *cost*: Work obtained Energy consumed

$$\eta =$$

For an **engine**:

$$\eta = \frac{W}{Q_1} = \frac{Q_1 - |Q_2|}{Q_1} = 1 - \frac{|Q_2|}{Q_1} < 1$$

It can be demonstrated that the thermal efficiency of an **ideal thermal engine** (called **Carnot engine**) depends only of the temperature of both foci:

which is the maximum efficiency that can be obtained from a thermal cycle operating between two sources with these temperatures.

Internal combustion engine

It is a **thermal engine** of **internal combustion** produced by an electric spark. It can be considered at a **constant volume**. The most used internal combustion engine is the **four**stroke piston engine (gasoline), being the Otto cycle the most used approximation:





Heat engines

Figure 1. Diagram of a heat engine. The engine absorbs heat from the hot source T_1 and releases heat to

$$\eta_{\text{ideal}} = 1 - \frac{T_2}{T_1},$$