

**CONCEPT** In this lesson on the laws of thermodynamics and fundamentals of efficiency, students will learn the basic principles governing energy transfer and conversion. The lesson will begin with an introduction to the three laws of thermodynamics, including the conservation of energy, the tendency of energy to move from high to low concentrations, and the impossibility of achieving absolute zero temperature.

## BACKGROUND

The laws of thermodynamics have a long and rich history, dating back to the 19th century. The first and second laws were developed in the mid-1800s by physicists such as William Thomson and Rudolf Clausius, and the third law was formulated in the early 20th century by Walther Nernst. The name 'zeroth law' was invented by Ralph H. Fowler in the 1930s, long after the first, second and third laws were widely recognized. These laws provide the fundamental principles that govern energy transfer and conversion, and have been applied in countless fields, from physics and chemistry to engineering and environmental science.

## EXAMPLES

**FIRST LAW OF THERMODYNAMICS:** Energy cannot be created or destroyed, only transformed from one form to another. For example, the energy in a piece of coal is transformed into heat energy when it is burned in a power plant to generate electricity.

**SECOND LAW OF THERMODYNAMICS:** In any energy conversion process, some energy will inevitably be lost as heat, making it impossible to achieve 100% efficiency. For example, when gasoline is burned in an internal combustion engine, some of the energy is lost as heat through the exhaust system.

**THIRD LAW OF THERMODYNAMICS:** As temperature approaches absolute zero, the entropy of a system approaches a minimum value. This principle is important in fields such as cryogenics, where materials are cooled to extremely low temperatures in order to achieve certain properties or behaviors.

**EFFICIENCY OF A CARNOT ENGINE:** The efficiency of a heat engine is determined by the difference between the high temperature and low temperature reservoirs. The maximum theoretical efficiency of a Carnot engine is given by  $(T_h - T_l)/T_h$ , where  $T_h$  is the high temperature and  $T_l$  is the low temperature.

*Make sure it measures up*

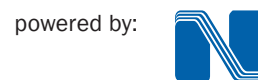
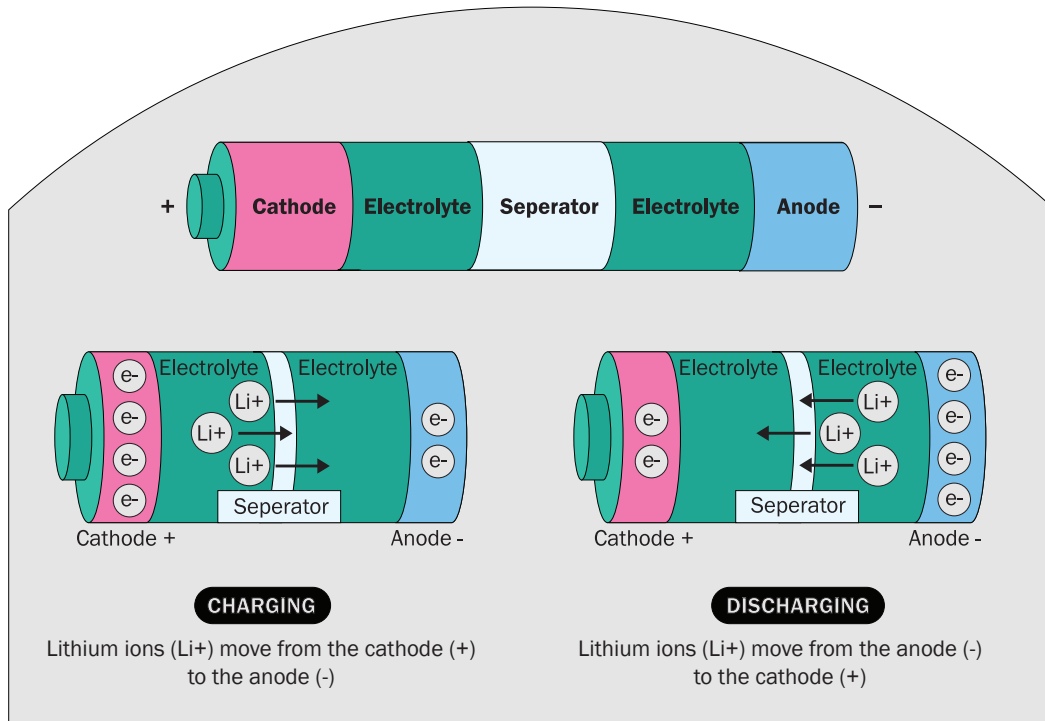
## APPLICATION

One application of the laws of thermodynamics and fundamentals of efficiency is in the development of fuel-efficient vehicles. For example, hybrid vehicles use a combination of gasoline or diesel engines and electric motors to reduce fuel consumption and emissions.

The first and second laws of thermodynamics are important in understanding how energy flows in a hybrid vehicle. The gasoline or diesel engine converts chemical energy in the fuel into mechanical energy to power the vehicle, while the electric motor uses electrical energy stored in batteries to provide additional power to operate the vehicle at low speeds. The energy transfer and conversion processes in the vehicle are subject to the laws of thermodynamics, which in turn determine the system's efficiency.

The third law of thermodynamics is also relevant in the development of more efficient electric and hybrid vehicles, particularly in the design of more efficient batteries. Researchers are working to develop new battery technologies that can store more energy and increase efficiencies, which can help minimize range anxiety associated with EVs and decrease emissions of hybrid vehicles.

Overall, the laws of thermodynamics and fundamentals of efficiency are essential principles which must be taken into account throughout a vehicle's development life cycle. By applying these principles, engineers and scientists are working to design more efficient and sustainable transportation systems.



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