15-4 The Second Law of Thermodynamics – Introduction

The absence of the process illustrated above indicates that conservation of energy is not the whole story. If it were, movies run backwards would look perfectly normal to us!

15-4 The Second Law of Thermodynamics – Introduction

The second law of thermodynamics is a statement about which processes occur and which do not. There are many ways to state the second law; here is one:

Heat can flow spontaneously from a hot object to a cold object; it will not flow spontaneously from a cold object to a hot object.

15-5 Heat Engines

It is easy to produce thermal energy using work, but how does one produce work using thermal energy?

This is a heat engine; mechanical energy can be obtained from thermal energy only when heat can flow from a higher temperature to a lower temperature.

15-5 Heat Engines

A steam engine is one type of heat engine.

15-5 Heat Engines

The internal combustion engine is a type of heat engine as well.

The efficiency of the heat engine is the ratio of the work done to the heat input:

\[ e = \frac{W}{Q_H} \]

Using conservation of energy to eliminate \( W \), we find:

\[ e = 1 - \frac{Q_l}{Q_H} \]
15-5 Carnot Cycle

1. Isothermal expansion
2. Adiabatic expansion
3. Isothermal compression
4. Adiabatic compression

15-5 Heat Engines

For an ideal reversible engine:

\[ \epsilon_{\text{ideal}} = \frac{T_H - T_L}{T_H} = 1 - \frac{T_L}{T_H} \quad (15-5) \]

- T in Kelvin!!!
- 100% efficiency can be achieved only if the cold reservoir is at absolute zero, which is impossible.
- Real engines have some frictional losses; the best achieve 60-80% of the Carnot value of efficiency.

15-6 Refrigerators, Air Conditioners, and Heat Pumps

These appliances can be thought of as heat engines operating in reverse.

By doing work, heat is extracted from the cold reservoir and exhausted to the hot reservoir.

15-6 Refrigerators, Air Conditioners, and Heat Pumps

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