WEEK 15

Physics of Engineer

Chapter 13: ideal gas and pure substance, work and heat

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Outline

- Work and heat
- Introduction
- Work – physical meaning
- Type of work
- Power
- Heat – physical meaning
- Heat – definitions & units
- Specific heat capacity

Outline

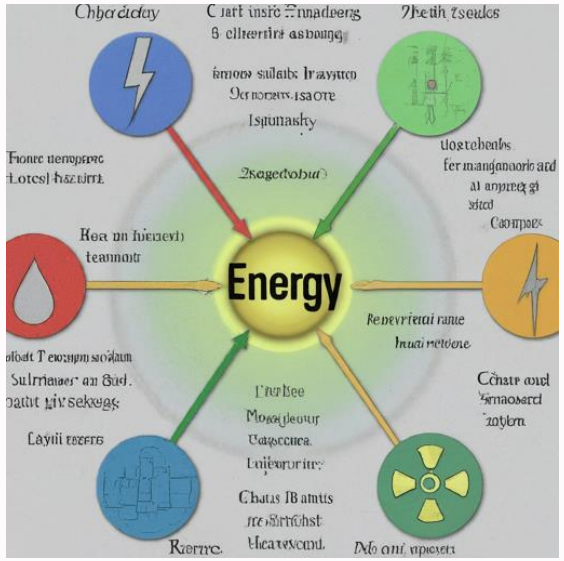
- Sign convection for heat
- Latent heat
- First law of thermodynamics
- Internal energy
- Application of work and heat
- Conclusion
- Exploring Resources and references

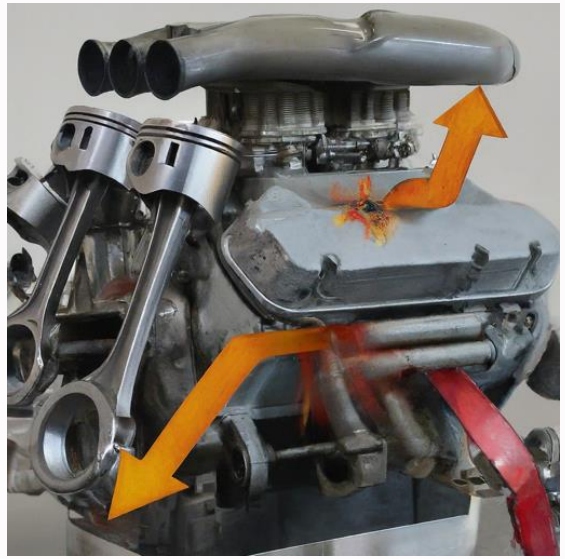
NPRU

Work and Heat

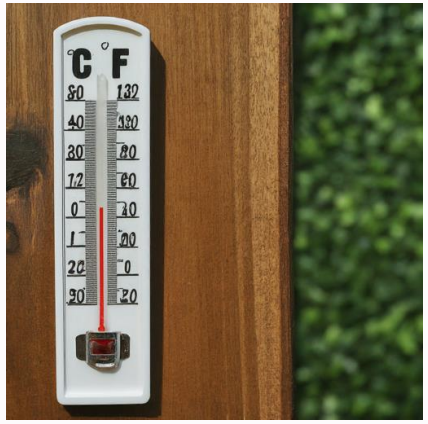
Introduction

- What is Energy?
- The Relationship Between Work and Heat
- Why Study Work and Heat?





Introduction



- **Content:**
  - Thermodynamics is the branch of physics concerned with the relationship between heat, work, temperature, and energy.
  - Work and heat are two fundamental ways energy is transferred between a system and its surroundings.
  - Understanding work and heat is crucial in various engineering and scientific applications.

Work - Physical Meaning

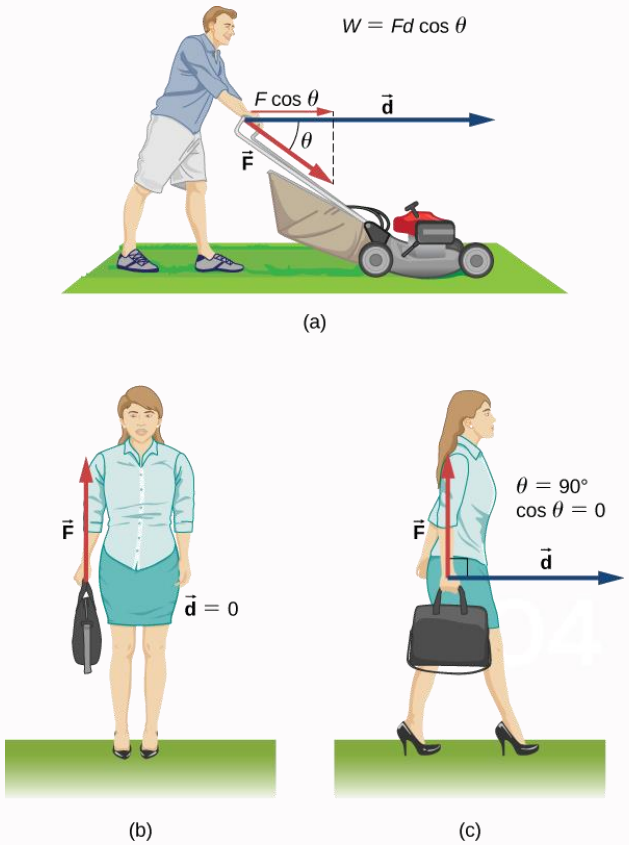
Image: https://www.vocabulary.cl/Lists/Daily_Routines.htm

Image: https://selftution.com/work-and-energy-in-physics-definition-examples-joule/

- What is Work?
- Everyday Examples of Work

Work - Physical Meaning

- Work refers to the transfer of energy between a system and its surroundings due to a macroscopic force acting through a distance.
- Imagine pushing a box across the floor. The force you exert (macroscopic) causes the box to move (distance), resulting in work done.

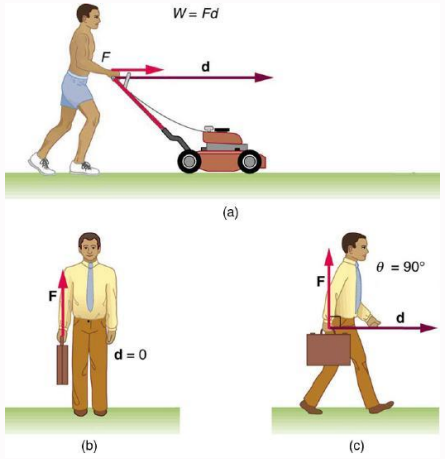


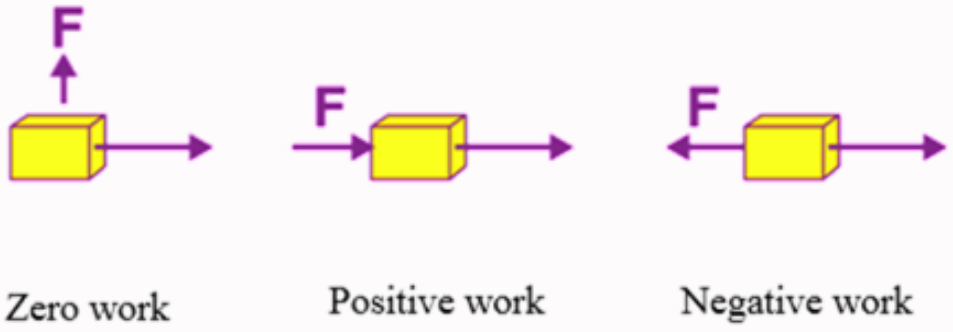
Work - Physical Meaning

- **Physical Meaning:** Force acting on an object through a distance.
- **Definition:** Work (W) is the scalar product of the force (F) and the displacement (s) of the object, formula for work:
  - Constant Force: $W = F \cdot s$
  - Variable Force: $W = \int F \cdot ds$
- **Unit:** The SI unit of work is the Joule (J).
  - 1 Joule is equal to the work done by a force of 1 Newton (N) acting through a displacement of 1 meter (m).
  - Other commonly used units include kilojoule (kJ) and calorie (cal).

Types of Work

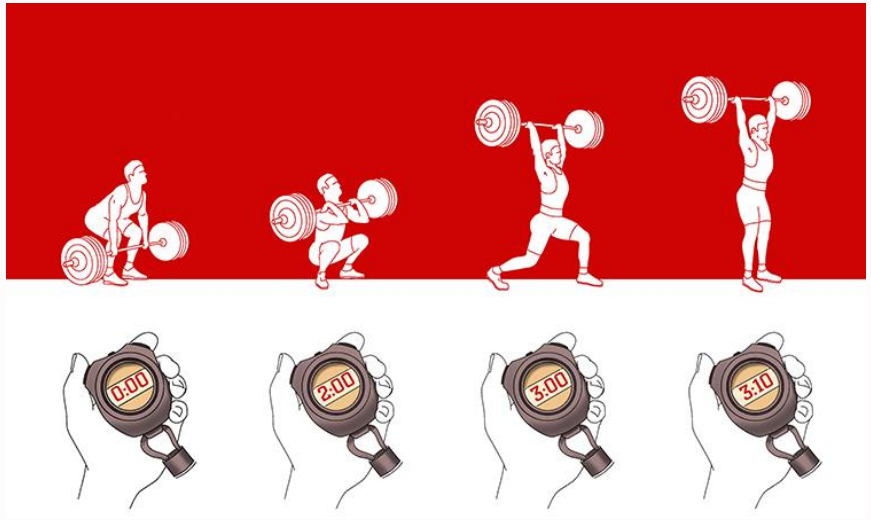
- **Positive work** (W > 0) is done when the force applied is in the same direction as the displacement of the object. (e.g., Lifting a weight)
- **Negative work** (W < 0) is done when the force applied is in the opposite direction of the displacement. (e.g., Lowering a weight by a rope)
- **Zero Work** (W = 0) When the force is applied perpendicular to the displacement or there is no displacement.



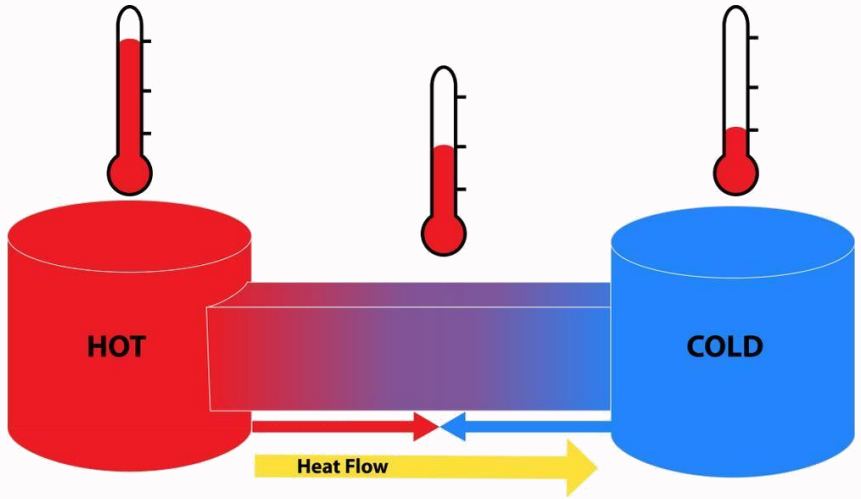


Power

- **Definition:** Rate at which work is done. Define power as the amount of work done per unit time.
- **Unit:** Watt (W)
- **Equation:** P = W / t



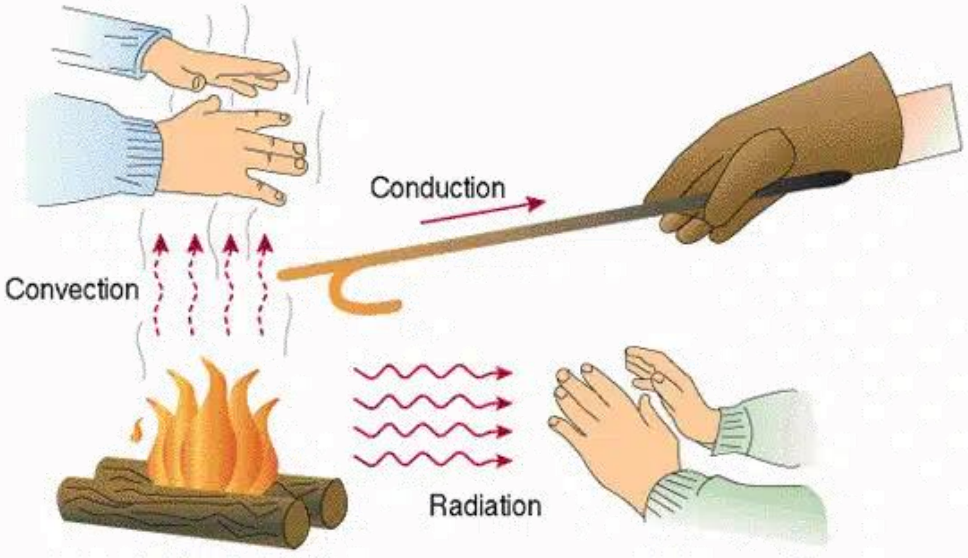
Heat - Physical Meaning

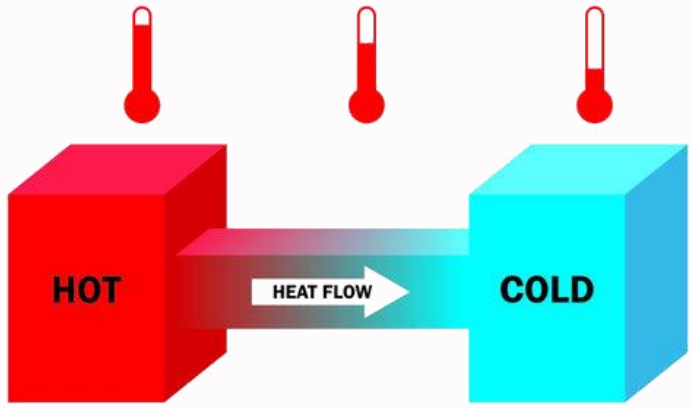


- What is Heat?
- Thermal Equilibrium
- Heat Flow

Heat - Physical Meaning

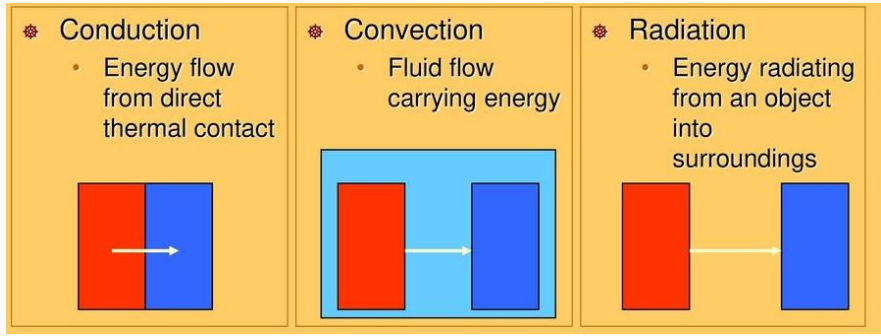
- **Content:**
  - Heat (Q) refers to the transfer of thermal energy between a system and its surroundings due to a temperature difference.
  - Heat flows from a higher temperature region to a lower temperature region, tending to establish thermal equilibrium.

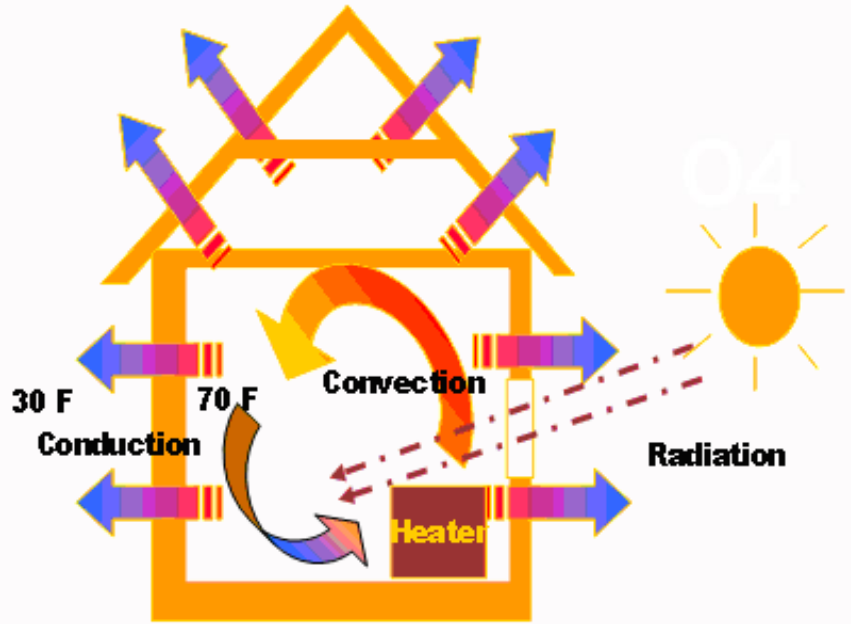




Heat – Definitions & Units

- Content: Heat is not a property of a system, but rather the transfer of thermal energy.
- The amount of heat transferred depends on the temperature difference and the properties of the materials involved.
- The SI unit of heat is also the Joule (J), consistent with work.
- This reflects that both work and heat are energy transfer mechanisms.
- Other commonly used units for heat include calorie (cal) and British

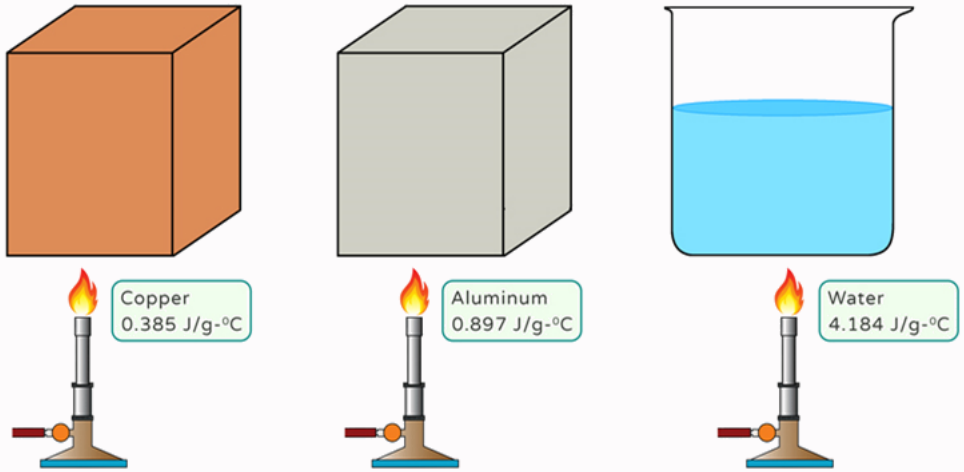


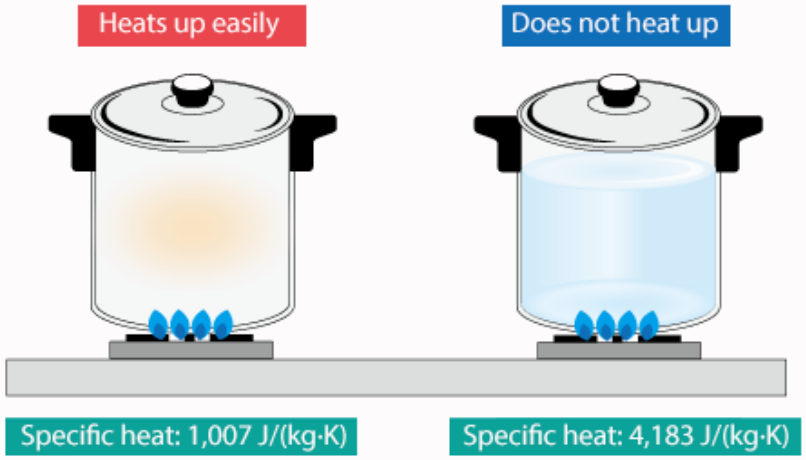


Specific Heat Capacity

- Definition: The amount of heat required to raise the temperature of 1 gram of a substance by 1 degree Celsius (°C).
- Unit: J/g°C
- Equation: $Q = mc\Delta T$

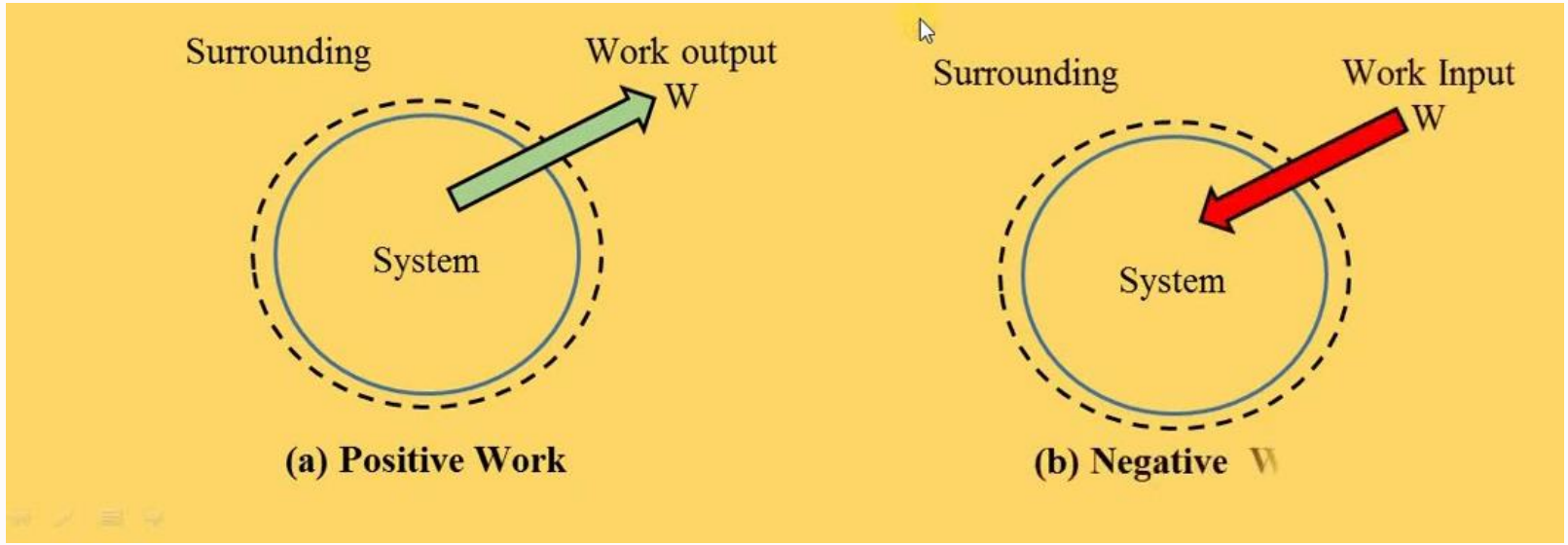
where m is mass, c is specific heat capacity, and ΔT is the change in temperature.





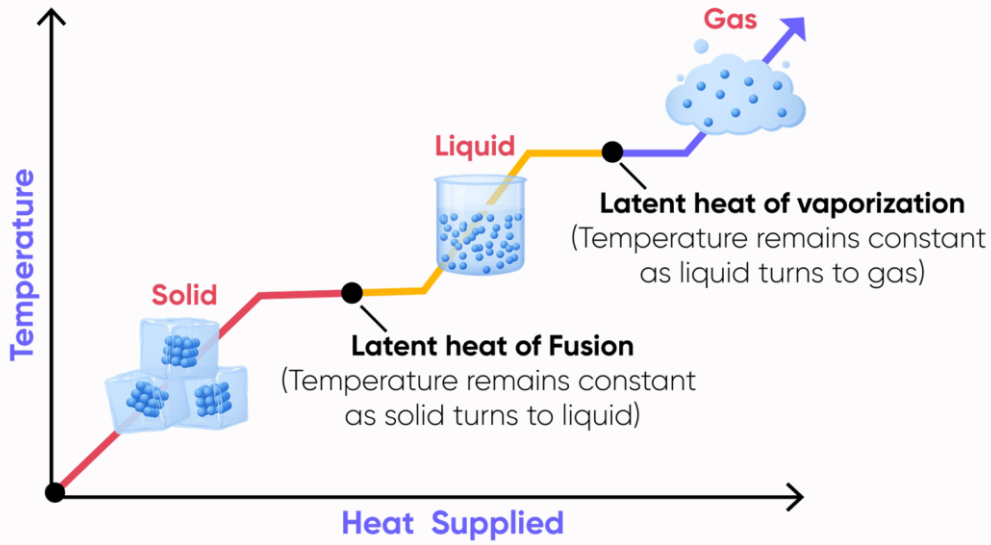
Sign Convention for Heat

- **Positive Heat:** Heat transferred to the system (increases its temperature).
- **Negative Heat:** Heat transferred from the system (decreases its temperature).



Latent Heat

- **Definition:** Heat absorbed or released during a change of state (e.g., solid to liquid, liquid to gas).
- **Units:** J/kg
- **Examples:** Latent heat of fusion (melting), latent heat of vaporization (boiling).

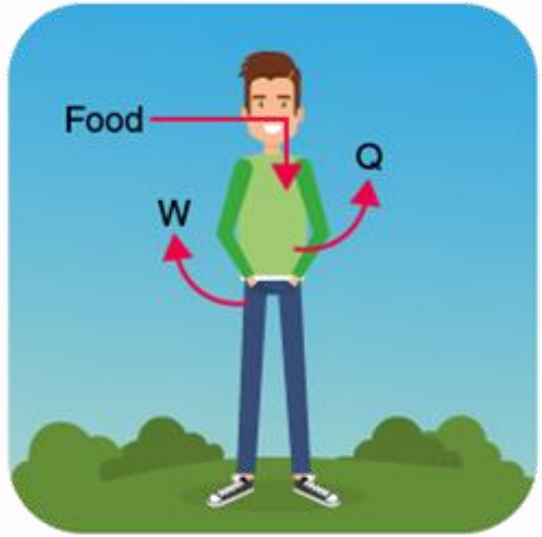


First Law of Thermodynamics

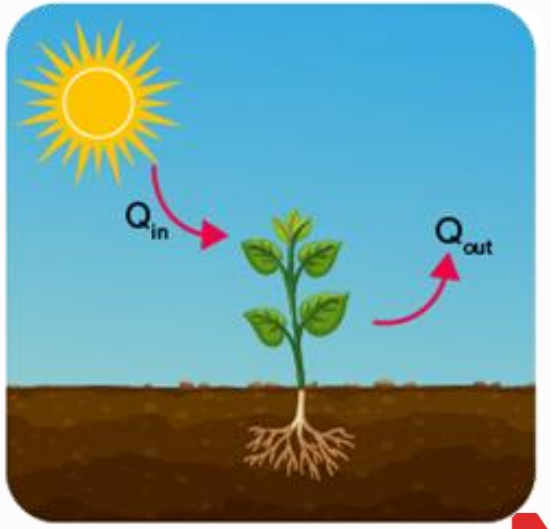
- **Statement:** The total energy of an isolated system remains constant. Energy can be transformed from one form to another (work ↔ heat), but it cannot be created or destroyed.
- **Equation:** $\Delta U = Q - W$

Where ΔU is the change in internal energy of the system, Q is the heat transferred to the system, and W is the work done by the system.

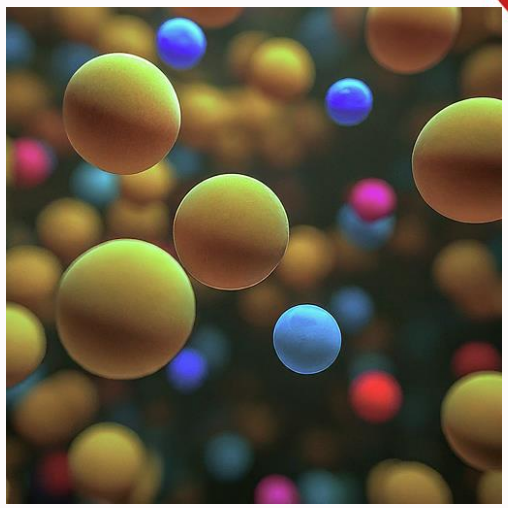
$\Delta U = -Q - W + \text{Food energy}$



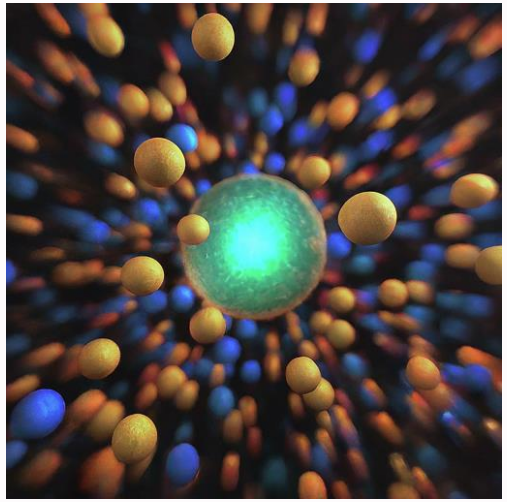
$\Delta U = \text{Stored food energy}$



Internal Energy

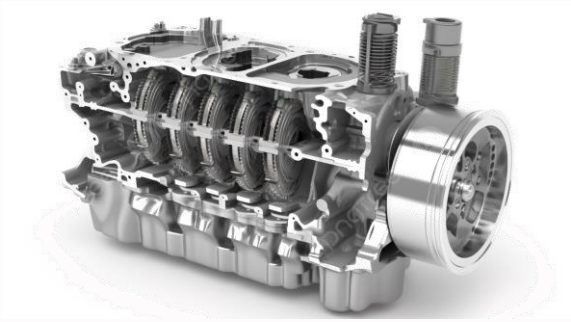


- **Definition:** The total kinetic and potential energy of the microscopic particles (atoms and molecules) within a system.
- **Units:** Joule (J)
- **Factors Affecting Internal Energy:** Temperature, volume, chemical composition.



Applications of Work and Heat

- **Power Generation:** Steam turbines in power plants convert heat energy from burning fossil fuels into mechanical work, which is then used to generate electricity.



- **Internal Combustion Engines:** Gasoline engines in cars utilize the heat released during combustion to perform work by moving pistons and driving wheels.
- **Refrigeration and Air Conditioning:** Heat pumps transfer heat from a cold reservoir (inside your home) to a hot reservoir (outside) using work input, achieving cooling.

Conclusion

- **Summary:** Work and heat are fundamental concepts in thermodynamics that govern energy transfer and transformation.
- **Importance:** Understanding work and heat is essential in various fields of science and engineering.
- **Further Exploration:** Encourage students to explore the resources provided for a deeper understanding of the topic.

Exploring Resources and References

- **Online Resources:**
  - Khan Academy: https://www.khanacademy.org/login (Thermodynamics section)
  - MIT OpenCourseware: https://ocw.mit.edu/ (Introduction to Thermodynamics)
  - Hyperphysics: http://hyperphysics.phy-astr.gsu.edu/ (Work and Heat concepts) (Speaker Notes: Provide a list of credible online resources for further learning about work and heat.)
- **Textbooks:**
  - Halliday, Resnick, and Krane: Fundamentals of Physics
  - Cengel and Boles: Thermodynamics: An Engineering Approach (Speaker Notes: Recommend relevant physics and thermodynamics textbooks for deeper understanding.)
- **Reference**
  - Halliday, D., Resnick, R., & Krane, K. S. (2010). *Fundamentals of Physics* (7th ed.). Wiley.

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