

Energy Flow in Technological Systems: Formative Quiz

Time: 25 min. 6 questions.

Instructions

Answer all six questions in the space provided or in your notebook. Show your work for the numeric question, including units at every step. Read each question carefully before answering, and use full sentences for the short answer items.

Questions

1. Which of the following best describes how the concept of energy developed historically, according to the study of thermodynamics?

- A) The laws of thermodynamics were formulated first, and engineers then used them to design the first heat engines.
- B) Steam engines and other heat-based technologies were built through trial and error before the laws of thermodynamics were formally stated.
- C) The concept of energy was unrelated to the invention of engines.
- D) Aboriginal technologies based on thermal energy transfer were developed after European heat engines.

[\(Outcome\)](#)

2. A furnace converts the chemical potential energy stored in natural gas into thermal energy used to heat a home. Explain, using the term "useful energy," why not all of the energy released by burning the gas ends up heating the house.

[\(Outcome\)](#)

3. True or false: According to the second law of thermodynamics, it is possible to design a heat engine that converts 100% of its energy input into useful work.

[\(Outcome\)](#)

4. A 2.0 kg textbook is lifted from the floor to a shelf 1.5 m above the floor. Using $E_p = mgh$, with $g = 9.81 \text{ m/s}^2$, calculate the gravitational potential energy gained by the textbook, in joules.

[\(Outcome\)](#)

5. Which historical development is most closely associated with improvements in engine efficiency that followed from applying thermodynamic principles?

- A) The investigations of Rumford and Joule into the relationship between heat and mechanical work
- B) The invention of the fuel cell in the twentieth century
- C) The discovery of solar heating panels
- D) The construction of the first hydroelectric dam

[\(Outcome\)](#)

6. Choose one technological system (for example, an automobile, a bicycle coming to a stop, or a refrigerator) and describe, in terms of energy transformations, what happens to the input energy as it moves through the system. Identify at least one point where useful energy is lost.

[\(Outcome\)](#)

Curriculum coverage

Question	Outcome alias
1	Outcome
2	Outcome
3	Outcome
4	Outcome
5	Outcome
6	Outcome

Answer key

1. B) Steam engines and other heat-based technologies were built through trial and error before the laws of thermodynamics were formally stated. The specific outcome states that technologies based on thermodynamic principles were developed before the laws of thermodynamics were formulated ([Outcome](#)).

2. Some of the chemical potential energy is converted to forms other than the thermal energy that heats the house, such as heat lost through the flue or the furnace casing, so only part of the total energy released counts as "useful" for heating purposes. The outcome defines useful energy operationally and requires students to recognize that not all converted energy is useful ([Outcome](#)).

3. False. The second law of thermodynamics establishes that no heat engine can convert 100% of its energy input into useful work, which explains why real engines are always less than fully efficient ([Outcome](#)).

4. Approximately 29 J ($E_p = mgh = 2.0 \text{ kg} \times 9.81 \text{ m/s}^2 \times 1.5 \text{ m} = 29.4 \text{ J}$). This applies the relationship $E_p = mgh$ from the outcome on quantifying gravitational potential energy ([Outcome](#)).

5. A) The investigations of Rumford and Joule into the relationship between heat and mechanical work. The outcome explicitly cites Rumford and Joule as key to developing the concept of energy from observations of heat and mechanical devices ([Outcome](#)).

6. Answers will vary but must trace the input energy through at least two transformation stages and identify a point of energy loss, for example a bicycle's kinetic energy converting to thermal energy through friction as it comes to a stop. The outcome requires students to describe energy transformations occurring in devices and systems and to recognize limits on useful energy conversion ([Outcome](#)).