

Formative Assessment: Energy Flow in Technological Systems

Time: 30 min. 6 questions.

Instructions

Answer all six questions in the space provided or on a separate sheet. Show all calculations for the numeric question, including units and significant digits. Where a question asks for an explanation, write in complete sentences and use correct scientific terminology.

Questions

1. Which of the following best illustrates a technology developed through a process of trial and error before the laws of thermodynamics were formally stated?

- A) James Watt's improvements to the steam engine's valve design
- B) A modern quantum computer processor
- C) A solar photovoltaic panel
- D) A nuclear fission reactor core

([Outcome](#))

2. Define kinetic energy and potential energy in your own words. Give one example of chemical energy as a form of potential energy. ([Outcome](#))

3. True or false: In the absence of resistive forces, motion at constant speed requires an ongoing input of energy. ([Outcome](#))

4. According to the first and second laws of thermodynamics, why are heat engines never 100% efficient?

- A) Energy is destroyed as the engine operates, reducing the total energy available.
- B) Some of the input energy is always converted to heat that cannot be used to do useful work.
- C) Friction removes all of the energy from the system almost immediately.
- D) Heat engines violate the law of conservation of energy by design.

([Outcome](#))

5. Explain, using the concept of "useful" energy, why a technological device such as a hydroelectric dam cannot convert 100% of the potential energy of stored water into useful electrical energy. Give one form of energy that is inevitably lost during this process. ([Outcome](#))

6. A 2.0 kg object is released from rest and falls freely through a height of 5.0 m, with air resistance considered negligible. Using $E_p = mgh$ and $g = 9.8 \text{ m/s}^2$, calculate the kinetic energy of the object, in joules, just before it strikes the ground. ([Outcome](#))

Curriculum coverage

Question	Outcome alias
1	Outcome
2	Outcome
3	Outcome

4	Outcome
5	Outcome
6	Outcome

Answer key

1. A) James Watt's improvements to the steam engine's valve design. Watt's engine improvements arose from iterative trial and error before thermodynamic laws were formalized, as identified in [Outcome](#).
2. Kinetic energy is energy due to motion; potential energy is energy due to relative position or condition. An acceptable example of chemical potential energy is energy stored in glucose, ATP, or gasoline, as defined in [Outcome](#).
3. False. Node:n1 states that in the absence of resistive forces, motion at constant speed requires no energy input, since there is no opposing force to work against.
4. B) Some of the input energy is always converted to heat that cannot be used to do useful work. Node:n3 explains that the first and second laws of thermodynamics account for why heat engines cannot reach 100% efficiency.
5. Not all potential energy converts to useful electrical energy because some energy is always converted to a non-useful form, typically heat, during each stage of the conversion process. This reflects the limit on "useful" energy described in [Outcome](#), using the hydroelectric dam example.
6. 98 J. Since $E_p = mgh = W = Fd = \frac{1}{2}mv^2$ for an object falling from rest, E_k at the bottom equals E_p at the top: $E_k = mgh = 2.0 \text{ kg} \times 9.8 \text{ m/s}^2 \times 5.0 \text{ m} = 98 \text{ J}$, applying the relationship given in [Outcome](#).