

Energy Flow in Technological Systems

This worksheet covers concepts from Science 10 Unit B, including forms of energy, work and mechanical energy calculations, and the application of thermodynamic principles to the efficiency of technological systems ([Outcome](#), [Outcome](#), [Outcome](#)). Show all work for calculations, including formulas, substitutions and units.

Exercises

1. Matching: Energy Transformation Technologies

Match each technology on the left with the energy transformation it primarily performs ([Outcome](#)). Write the correct letter beside each number.

Technology	Answer	Energy Transformation
1. Hydroelectric generator	_____	A) Chemical energy !' thermal and kinetic energy
2. Solar heating panel	_____	B) Gravitational potential energy !' kinetic energy !' electrical energy
3. Windmill	_____	C) Radiant (solar) energy !' thermal energy
4. Automobile engine	_____	D) Kinetic energy (wind) !' mechanical energy !' electrical energy

2. Multiple Choice: Laws of Thermodynamics

Circle the letter of the best answer for each question ([Outcome](#)).

a) Why are heat engines never 100% efficient?

- A) Friction can always be eliminated with better lubrication
- B) Some energy input is always converted to heat that cannot be recovered as useful work
- C) The first law of thermodynamics prevents energy from being created
- D) Engines only convert kinetic energy to potential energy

b) A refrigerator transfers thermal energy from inside its compartment to the surrounding room. This process is best described as:

- A) a violation of the second law of thermodynamics
- B) an energy conversion in which useful work is done to move thermal energy against its natural direction of flow
- C) a system in which no energy input is required
- D) a process with 100% efficiency

3. Calculations: Work and Mechanical Energy

Use $g = 9.81 \text{ m/s}^2$ where needed. Show your formula, substitution and final answer with units ([Outcome](#)).

a) A 15 kg crate is lifted 3.0 m onto a shelf. Calculate the gravitational potential energy gained by the crate.

b) A 0.50 kg ball moves at 8.0 m/s. Calculate its kinetic energy.

c) A constant force of 25 N is applied to move an object a distance of 4.0 m. Calculate the work done on the object.

4. Short Answer: Definitions

Answer each question in one or two complete sentences ([Outcome](#)).

a) Define kinetic energy and potential energy, and give one example of each that is not already used in this worksheet.

b) Explain the difference between a scalar quantity and a vector quantity, using speed and velocity as your example.

5. Efficiency Problem

A gasoline engine takes in 500 kJ of chemical energy from fuel and produces 150 kJ of useful mechanical work. The rest is lost mainly as heat ([Outcome](#)).

a) Calculate the efficiency of the engine as a percentage. Show your formula and substitution.

b) Explain, in terms of the laws of thermodynamics, why the remaining energy cannot be fully converted to useful work.

6. Applied Reasoning: Historical Development

Answer in complete sentences ([Outcome](#), [Outcome](#)).

a) Explain how trial-and-error improvements to early engine designs, such as the work of James Watt, contributed to the eventual formulation of the laws of thermodynamics.

b) Describe one historical or Aboriginal technology that made use of thermal energy transfer before the scientific principles behind it were formally understood.

Answer key

1. 1-B, 2-C, 3-D, 4-A

2. a) B, b) B

3. a) $E_p = mgh = 15 \text{ kg} \times 9.81 \text{ m/s}^2 \times 3.0 \text{ m} = 440 \text{ J}$ (441.45 J rounded to two significant digits); b) $E_k = \frac{1}{2} mv^2 = 0.5 \times 0.50 \text{ kg} \times (8.0 \text{ m/s})^2 = 16 \text{ J}$; c) $W = Fd = 25 \text{ N} \times 4.0 \text{ m} = 100 \text{ J}$

4. a) Kinetic energy is energy due to motion; potential energy is energy due to relative position or condition. Accept any valid example for each, such as a moving car (kinetic) or a stretched spring (potential). b) A scalar quantity has magnitude only (speed), while a vector quantity has both magnitude and direction (velocity).

5. a) $\text{Efficiency} = (\text{useful energy output} \div \text{total energy input}) \times 100\% = (150 \text{ kJ} \div 500 \text{ kJ}) \times 100\% = 30\%$. b) The second law of thermodynamics states that some energy is always converted to heat during a conversion process and cannot be fully recovered as useful work, so no real engine can reach 100% efficiency.

6. a) Answers should describe how improvements such as better valve designs or Watt's modifications increased engine efficiency through practical experimentation, and how

understanding these mechanical improvements led scientists to formalize the relationships between heat, work and energy as the laws of thermodynamics. b) Accept any valid example, such as pre-contact First Nations or Inuit use of insulated shelters, tool-making techniques, or permafrost storage pits that made practical use of thermal energy transfer.