Energy flow in technological systems slide deck

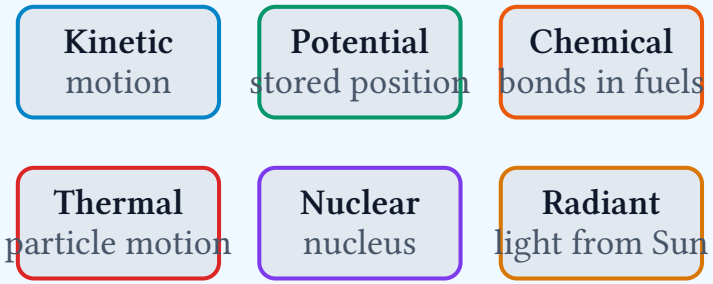
Science 10

Unit B: Energy flow in technological systems

Forms of energy

Locating energy

- A falling ball, a burning candle, and a solar panel all involve energy, and each one shows a different form.
- Alberta classrooms: furnace heat, bus fuel, wind turbines on the horizon.



· transforms between forms: total energy is conserved in a closed

Energy as a measured property

- Energy is a property we measure in a system, like its speed or temperature.
- Solar energy is radiation from the Sun, and it is Earth's main incoming supply.

Key terms

mechanical energy

Energy associated with motion or position.

chemical energy

Potential energy associated with the arrangement of atoms and bonds.

thermal energy

Energy associated with the random motion and interactions of particles in a system.

nuclear energy

Energy associated with changes in atomic nuclei.

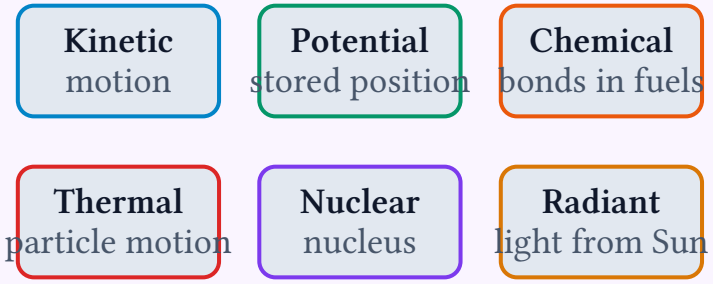
Key terms

solar energy

Electromagnetic energy transferred from the Sun.

Five forms of energy

- Mechanical energy is the energy of motion and of position.
- Chemical energy is stored in fuels, food, and ATP.
- Thermal energy is the energy of particle motion, which shows up as a temperature change.
- Nuclear energy comes from changes in the nucleus, as in a reactor or in the Sun.
- Solar energy is the radiation that arrives from the Sun.



· transforms between forms: total energy is conserved in a closed

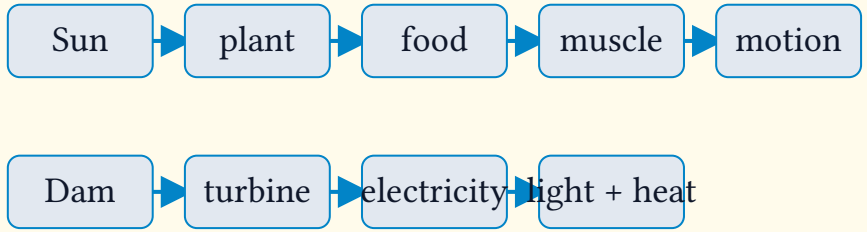
Observing energy

- You notice energy when it transfers from one place or form to another.
- Look for changes in motion, shape, temperature, or light.
- Constant temperature and constant speed (no friction): no net energy transfer into the system.



An energy chain

- Follow sunlight stored in wheat, then in bread, then in a student's motion and body heat.
- Name the form at each stage, and name the evidence you would actually observe.

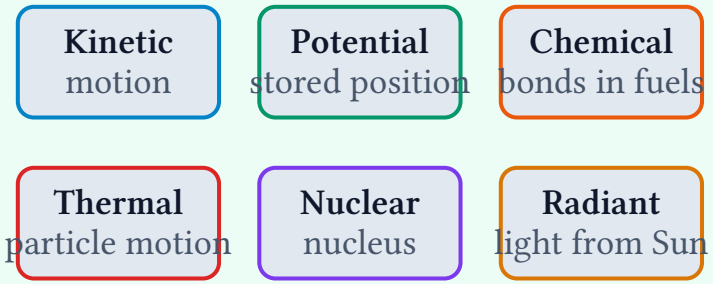


Each step: measurable changes in temperature, motion, or light

Alberta examples: hydro, oil sands upgrading, wind, solar farms

Station classification

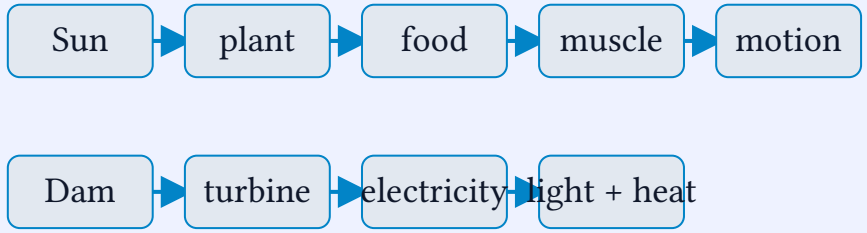
- At each station, name the dominant energy form and the evidence you can observe.
- Include at least one technology and one example from outside a machine.



· transforms between forms: total energy is conserved in a closed

Alberta energy contexts

- Hydro, natural gas, wind, and solar installations transform energy for communities.
- Discuss why naming the form matters for engineers and environmental stewards.

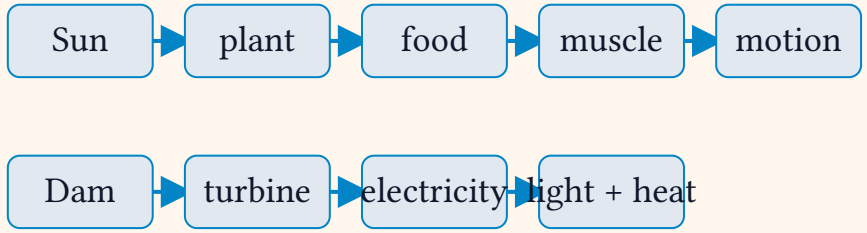


Each step: measurable changes in temperature, motion, or light

Alberta examples: hydro, oil sands upgrading, wind, solar farms

Traditional technologies

- Indigenous tool making, structures, and heating use the same thermodynamic ideas.
- Efficient use of locally available materials reflects deep knowledge of energy transfer.



Each step: measurable changes in temperature, motion, or light

Alberta examples: hydro, oil sands upgrading, wind, solar farms

Form classification sort

- Teams sort examples into mechanical, chemical, thermal, nuclear, solar; defend one card.
- A complete answer gives evidence of transfer, such as motion, a temperature change, or light.

Energy-form retrieval check

- Trace energy from sunlight to wheat, food, a moving cyclist, and the surroundings.
- Classify the dominant energy evidence in a raised ball, a burning fuel, and warm water.
- Explain why a generator transforms energy from one form to another.

Image credits

USFWS Mountain-Prairie, Sunset Storm with Lightning Over Seedskadee National Wildlife Refuge, public domain

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Unit B: Energy flow in technological systems

Energy transformation technologies

A hand crank lights a lamp

- Turning the crank produces electrical energy that makes the lamp emit light and thermal energy.
- The crank becomes harder to turn when the generator supplies more electrical power.

Function of a generator

- A generator transforms mechanical energy into electrical energy; total energy is conserved.
- Mechanical energy enters; electrical energy carries the transfer; light and thermal energy leave.
- Trace energy transformations in technologies and identify measurable evidence at each step.

Key terms

energy transformation

A change from one energy form to another within a system.

energy transfer

Movement of energy across a system boundary.

generator

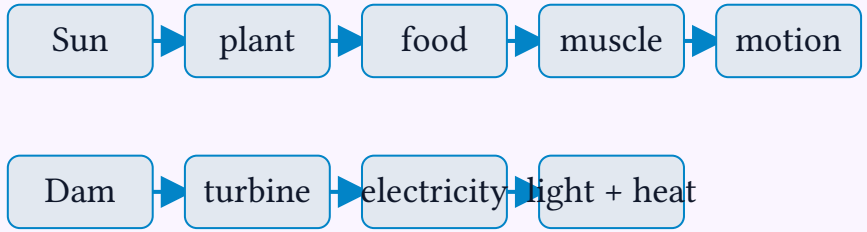
A device that transforms mechanical energy into electrical energy.

turbine

A rotating device driven by moving fluid, such as water, steam, or air.

Transformation technologies

- Hydroelectric and coal generators; solar panels; windmills; fuel cells.
- Transfers produce observable changes in motion, shape, or temperature.

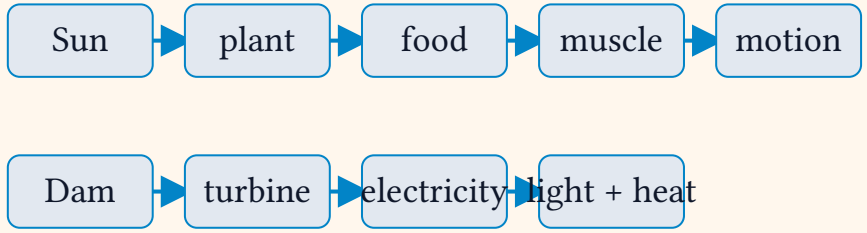


Each step: measurable changes in temperature, motion, or light

Alberta examples: hydro, oil sands upgrading, wind, solar farms

Indigenous technologies

- Tool making, building design, and heating all apply thermodynamic principles.
- Technology and trial-and-error precede formal laws.
- A scraper, a winter dwelling, and a fire each move energy in a way you can describe from the materials.



Each step: measurable changes in temperature, motion, or light

Alberta examples: hydro, oil sands upgrading, wind, solar farms

Technology and society

- Hydro and wind start with a moving fluid and end with electrical energy from a generator.
- A natural-gas plant starts with chemical energy, then combustion, motion, and generation.
- A region may use more than one system because fuel, water, and wind are found in different places.
- The local site changes. The energy accounting stays the same.



Energy chain of a technology

- Draw the energy chain for one technology and label one observable change at each transfer.
- A complete answer names the energy forms in order and cites evidence such as motion, a temperature change, or light.

Image credits

Royalbroil, Pincher Creek Summerview Wind Farm August 2013, CC BY-SA 4.0

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Unit B: Energy flow in technological systems

Engines and the idea of energy

Fuel use in Watt's engine

- Early steam engines repeatedly heated and cooled the same cylinder.
- Watt's separate condenser kept the working cylinder hotter and reduced wasted thermal transfer.



fficiency improvements drove industrial and transportation chang

Engines before the laws

- Practical engines came first; repeated observations and measurements helped scientists formulate the laws later.
- Less energy is used to reheat the cylinder during each cycle, so more input supports useful mechanical work.
- Connect trial-and-error engine improvements to the later formulation of thermodynamic laws.

Key terms

heat engine

A device that transforms thermal energy into mechanical work through a repeating cycle.

steam engine

A heat engine that uses steam pressure to drive mechanical motion.

efficiency

Useful energy output divided by total energy input, usually expressed as a percentage.

thermodynamics

The study of energy transfer, thermal processes, and work.

Invention of the engine

- Early heat engines improved when builders tried a change and measured whether it worked.
- Watt redesigned the engine so less heat was wasted reheating the cylinder each cycle.



fficiency improvements drove industrial and transportation chang

Concept of energy

- Rumford and Joule showed that mechanical work and heating are connected.
- First Nations and Inuit technologies using thermal energy transfer.
- People were already moving thermal energy with tools long before the laws were written down.



fficiency improvements drove industrial and transportation chang

Design change and evidence

- Explain one Watt design change and connect it to a reduced thermal-energy loss.
- A complete answer names one design change, compares before and after, and gives a physical reason the efficiency improved.

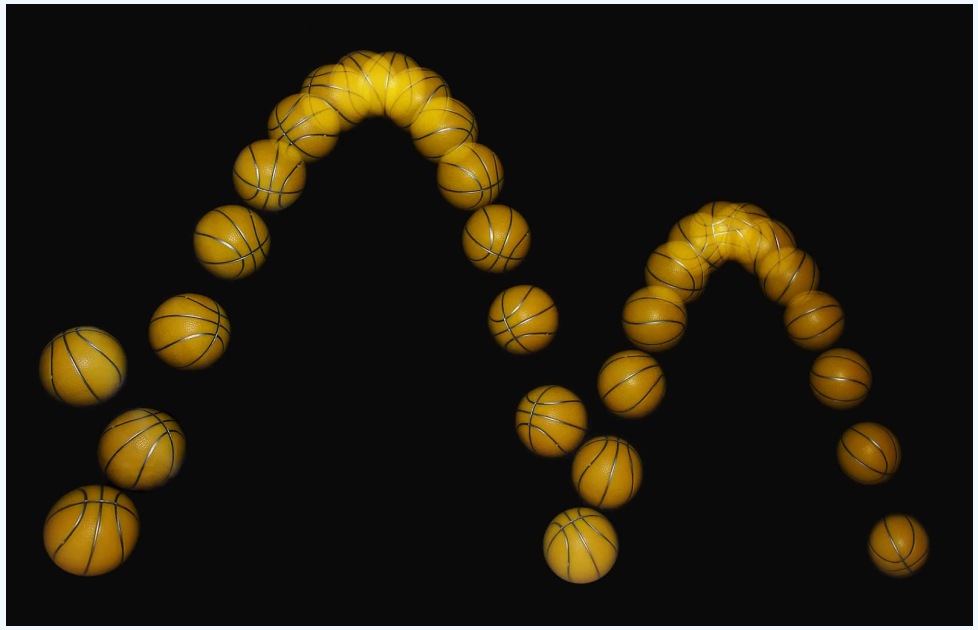
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Unit B: Energy flow in technological systems

Kinetic and potential energy

A ball at rest and in motion

- A ball held still above the floor has gravitational potential energy.
- After release, its speed increases as gravitational potential energy is transformed into kinetic energy.



Energy definitions

- In the opening case, the held ball has gravitational potential energy because of its height, even while it sits still.
- As the ball falls, gravitational potential energy decreases and kinetic energy increases.
- Above the floor, the moving ball has both.
- Food, batteries, and gasoline store chemical energy because reactions can change their particle arrangements.

Key terms

kinetic energy

Energy associated with an object's motion. (KE or E_k)

potential energy

Energy associated with position, arrangement, or condition. (PE or E_p)

chemical energy

Potential energy associated with the arrangement of atoms and bonds.

system

The object or group of objects chosen for an energy analysis.

Evidence of energy

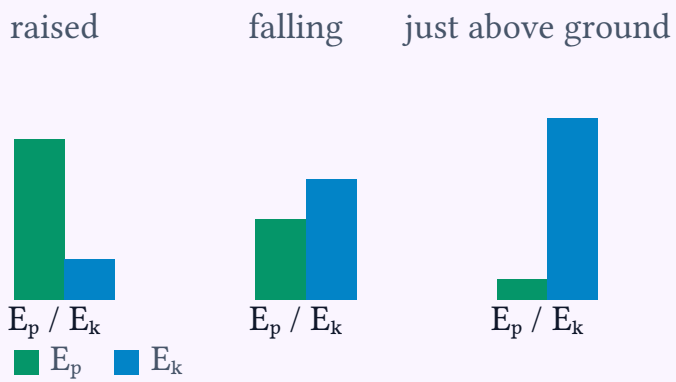
- You infer energy from a change you can measure.
- A change in speed supports a kinetic-energy description. A change in height or shape supports potential energy.
- Temperature, light, sound, or a new substance can show that energy moved or changed form.
- The evidence comes from what you observe. A battery might be charged, flat, or disconnected.



Energy is inferred from observable changes, not seen directly

Applying the energy definitions

- A rolling cart has kinetic energy (KE or E_k) because it is moving.
- A raised cart has gravitational potential energy (a form of PE or E_p) because of its height relative to the floor.
- Food, batteries, and gasoline have chemical energy because their particle arrangements can change during reactions.



Classifying with reasons

- Classify four scenarios and cite the observation or condition that supports each choice.
- A complete answer uses motion for kinetic energy, position or condition for potential energy, and chemical change for chemical energy.

Image credits

MichaelMaggs Edit by Richard Bartz, Bouncing ball strobe edit, CC BY-SA 3.0

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Unit B: Energy flow in technological systems

Scalars and vectors in motion

Distance and displacement on a lap

- A runner completes 400 m around a track and returns to the starting point.
- The distance is 400 m, but the displacement is 0 m because start and finish positions match.



Speed and velocity

- Speed is a scalar; velocity includes both speed and direction.
- Distance measures path length; displacement compares final and initial position and includes direction.
- Distinguish scalar and vector quantities and calculate displacement, velocity, and acceleration.

Key terms

scalar

A quantity described by magnitude and unit only.

vector

A quantity described by magnitude, unit, and direction.

displacement

Change in position from initial point to final point, including direction. (Δd)

velocity

Rate of change of displacement, including direction. (v)

Key terms

acceleration

Rate of change of velocity. (a)

Scalars and vectors

- Speed tells you how fast. Velocity tells you how fast and which way.
- A full lap can be a long distance with a displacement of zero.
- For a vector, write the size, the unit, and the direction.



ectors need magnitude and direction (displacement, velocity, force

Acceleration

- Acceleration is the change in velocity divided by the time that change takes: $a = \Delta v/\Delta t$.
- Speeding up, slowing down, or turning each count as an acceleration.
- With no friction or drag, an object already moving at constant velocity keeps moving without any push.

Acceleration

$a = \Delta v / \Delta t$



Speed up, slow down, or turn all change velocity

Displacement and velocity

- Calculate distance and displacement for a path, then state an average velocity with direction.
- A complete answer states the reference points, the direction, the units, and the difference between path length and change in position.

Image credits

Santeri Viinamäki, Athletics track start line numbers 1, 2, 3, CC BY-SA 4.0

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Unit B: Energy flow in technological systems

Work and the joule

Work in joules

- You do work when you speed something up or move it against an opposing force.
- Energy change on a system equals work done on it: $\Delta E = W$.

$$W = F \times d$$

work (J) = force (N) × displacement (m) in direction of force

$\Delta E = W$ on system · $E_p = mgh$ · $E_k = \frac{1}{2}mv^2$

push ⟶ box moves

Force and distance

- Force, work, and energy share equations, and the units have to match before the numbers do.
- Work uses $W = Fd$, and the answer is in joules only when the units already match.
- The check $mgh = \frac{1}{2}mv^2$ asks whether height lost shows up as speed gained.

Key terms

force

A push or pull that can change an object's motion or shape. (F)

work

Energy transferred when a force moves an object ($W = Fd \cos \theta$). (W)

gravitational potential energy

Energy associated with an object's position relative to a chosen reference level in a gravitational field. (E_p)

kinetic energy

Energy associated with an object's motion. (KE or E_k)

Key terms

joule

SI unit of energy and work (J).

Work and gravitational potential energy

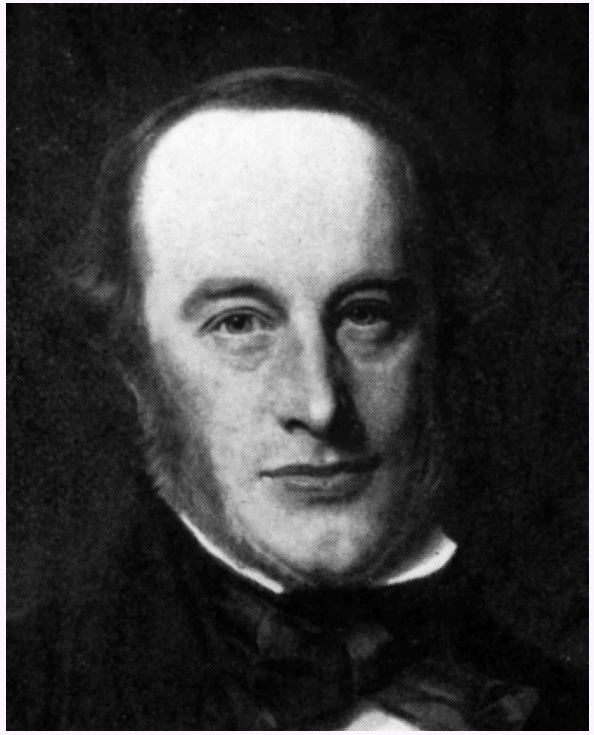
- Gravitational potential energy (E_p) is work done against gravity and is calculated with $E_p = mgh$.
- Mechanical work: $W = Fd$ when force and displacement align.
- Change in energy of a system equals work done on it.

Falling object

- From rest, gravitational potential energy lost over height h becomes kinetic energy gained when air resistance is ignored.
- The relationship $mgh = \frac{1}{2}mv^2$ asks whether height lost accounts for the speed gained.

The joule

- One joule is one newton-metre, which is also one kilogram metre squared per second squared.
- Energy and work use that same unit, so a work calculation can be compared with an energy change.



Practice set

- Calculate the gravitational potential energy of a 5 kg object on a 2 m shelf.
- Calculate the kinetic energy of a 3 kg object moving at 4 m/s.
- How much work is required to double the speed of an object that starts at rest?

Safety

Lab safety

- Keep feet and hands out of the path of a cart on a ramp.
- Clamp or brace the ramp before you measure its height.
- A rolling cart takes some of the energy as its own motion, which throws off the measurement.
- Stop the apparatus before you lean in to read a scale.

Work calculation

- Calculate work for 20 N over 3 m; compare to mgh for 2 kg raised 3 m (g ≈ 9.8 N/kg).
- A complete answer uses W = Fd with matching units and states the result in joules.

Work and energy retrieval check

- Calculate the work done by a constant 12 N force over 3.0 m in the force direction.
- Calculate gravitational potential energy gained by a 2.0 kg object raised 1.5 m.
- Explain why carrying a box horizontally at constant speed does no mechanical work on the box by the upward support force.

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Unknown photographer; ETH-Bibliothek Zürich, Image Archive, Joule, James Prescott (1818-1889), portrait, public domain

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Unit B: Energy flow in technological systems

Mechanical energy transformations

Height and speed on a ramp

- A cart released from a higher point reaches the bottom of a ramp at a greater speed.
- With small friction, decreasing gravitational potential energy corresponds to increasing kinetic energy.



Energy transformation with friction

- Potential energy is transformed mainly into kinetic energy and partly into thermal energy when friction acts.
- Measure release height and final speed while keeping the cart and ramp the same.
- Keep the cart and the ramp the same, link release height to final speed, and account for friction.

Key terms

mechanical energy

The sum of kinetic and potential energy in a mechanical system.

gravitational potential energy

Energy associated with position in a gravitational field. (E_p)

kinetic energy

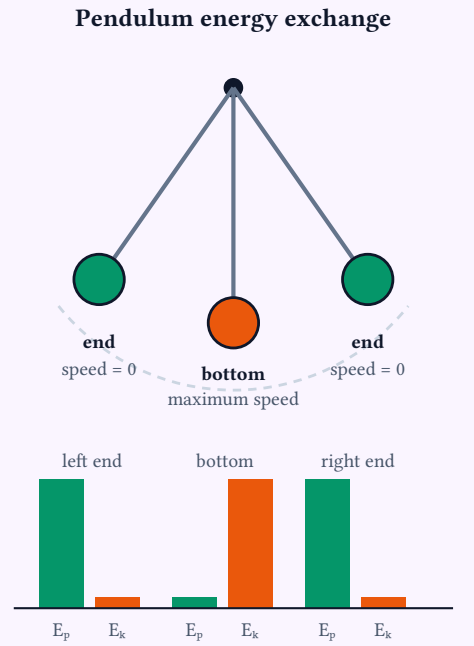
Energy associated with motion. (KE or E_k)

energy conservation

The principle that total energy stays constant as it transfers and transforms.

One-dimensional scalar motion

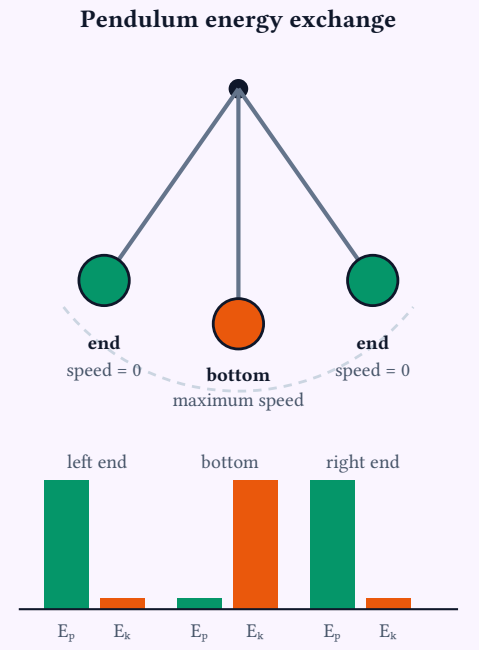
- In one dimension, distance, elapsed time, and velocity describe the motion.
- Work on that system is the force along the motion times the distance moved.



Ideal model: $E_p + E_k$ stays constant when friction is ignored.

Conservation in transformations

- In an ideal system, mechanical energy trades between kinetic energy and potential energy.
- In a real system, friction turns some of that energy into thermal energy.



Ideal model: $E_p + E_k$ stays constant when friction is ignored.

Ramp evidence

- Predict and compare final speed from two release heights, then explain differences using energy transformations.
- A complete answer keeps the variables controlled, links height to speed, and accounts for friction.

Image credits

Airtime Thrills Raw Footage, The drop of the roller coaster Orion, at Kings Island, CC BY 4.0

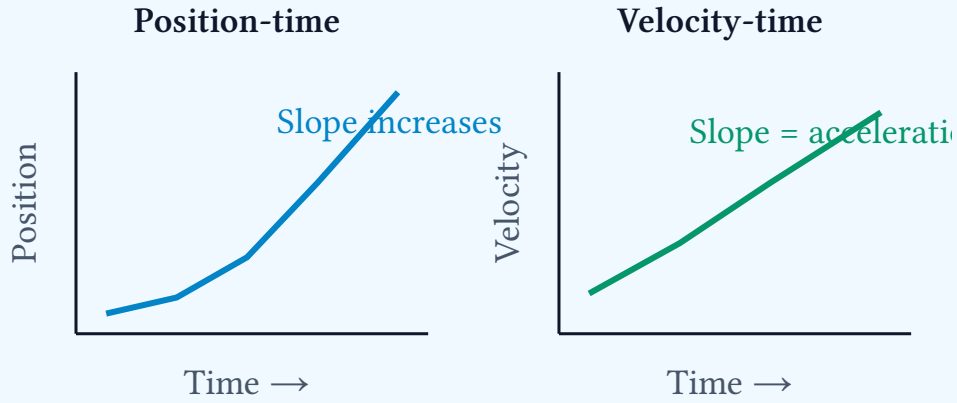
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Unit B: Energy flow in technological systems

Motion graphs and work

Motion graphs

- A steeper position-time line represents a greater speed.
- The area under a force-distance graph represents energy transferred as work.
- Read the axis labels before you decide whether a steep line means speed or acceleration.



Slope and area

- Meaning depends on the axes; on a position-time graph, the slope gives speed and the height of the line only gives location.
- Slope answers the speed question; area under the force-distance graph answers the work question.
- Interpret graph slope and area to describe motion, acceleration, and mechanical work.

Key terms

slope

Vertical change divided by horizontal change on a graph.

position-time graph

A graph showing position as a function of time.

velocity-time graph

A graph showing velocity as a function of time.

work

Energy transferred when a force acts through a displacement in its direction. (W)

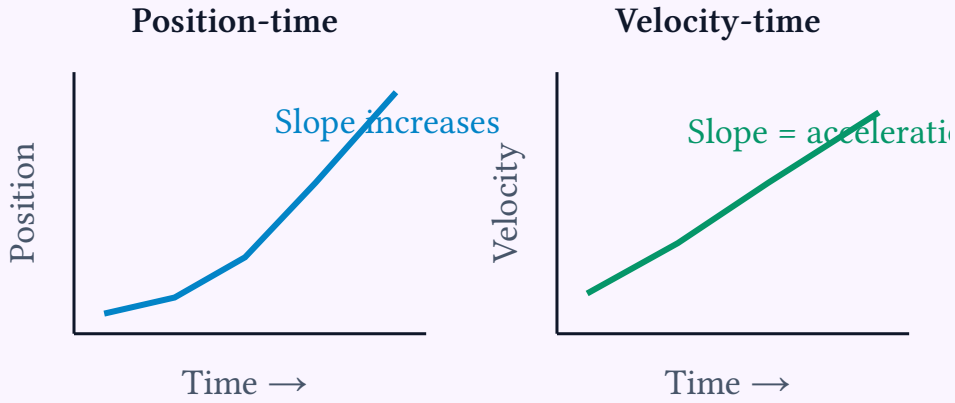
Key terms

area under a curve

The region between a graph line and the horizontal axis over an interval.

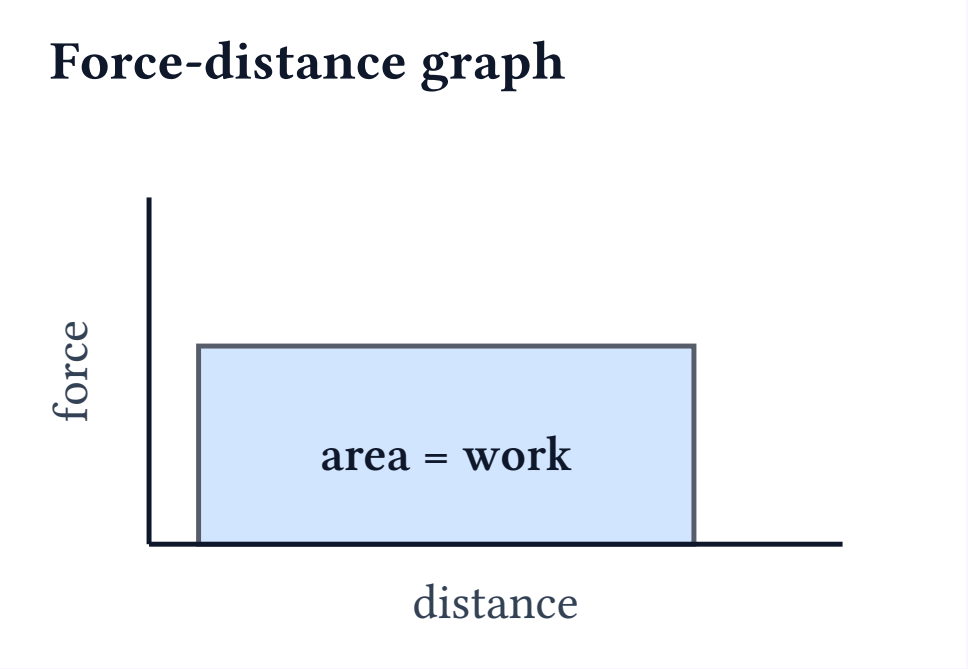
Velocity-time graphs

- On a velocity-time graph, the slope tells how quickly the velocity is changing.
- That change is the acceleration, and its sign depends on the direction you chose as positive.
- A horizontal line means the velocity is steady.



Force-distance graphs

- The area under a force-distance graph is the work done along that distance.
- A rectangle is a steady force. A triangle is a force that grows steadily from zero.
- Report that area in joules, and say which way the displacement points.



Practice

- Plot the points before you calculate.
- On a velocity-time graph, slope is acceleration and the area is displacement.
- On a force-distance graph, the area is work in joules.
- Check the axis labels before treating a slope as speed.

Slope and area

- Calculate one graph slope and one rectangular or triangular area, including units.
- A complete answer shows the rise over the run, the geometric area, and what that quantity means for motion or for joules.

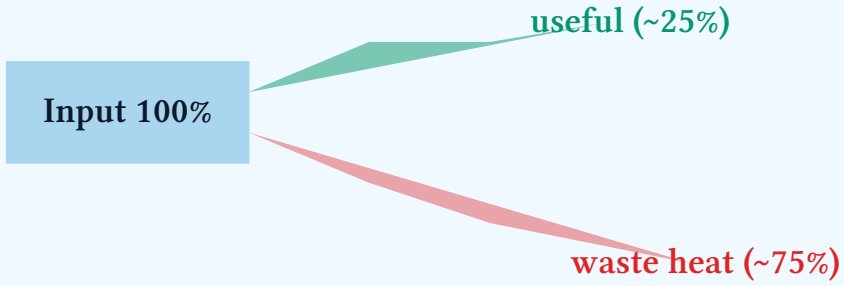
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Unit B: Energy flow in technological systems

Thermodynamic laws and useful energy

Purpose of a radiator

- Only part of the fuel energy becomes vehicle motion.
- The radiator and exhaust transfer thermal energy to the surroundings.
- Hidden energy, such as heat spread into the surroundings, still counts. It left through the radiator and the exhaust.



ıd law: some energy always spreads to surroundings as thermal eı

Conserved but less useful energy

- Inefficient devices conserve energy but transfer a larger fraction to non-useful outputs, often thermal energy.
- Total energy is conserved, but some spreads to the surroundings and is less available for useful work.
- Outputs sum to input and the second law is explained without saying energy vanished.

Key terms

first law of thermodynamics

Energy is conserved; it changes form or crosses system boundaries.

second law of thermodynamics

Energy transfers spread energy and reduce how much is available for useful work.

useful energy

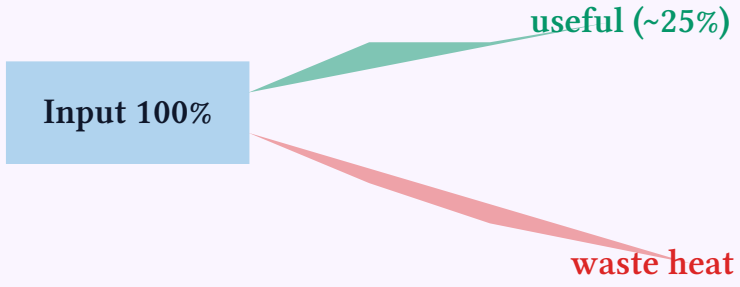
Energy delivered in the form intended for the device's purpose.

thermal transfer

Energy transferred because of a temperature difference.

Transformations in systems

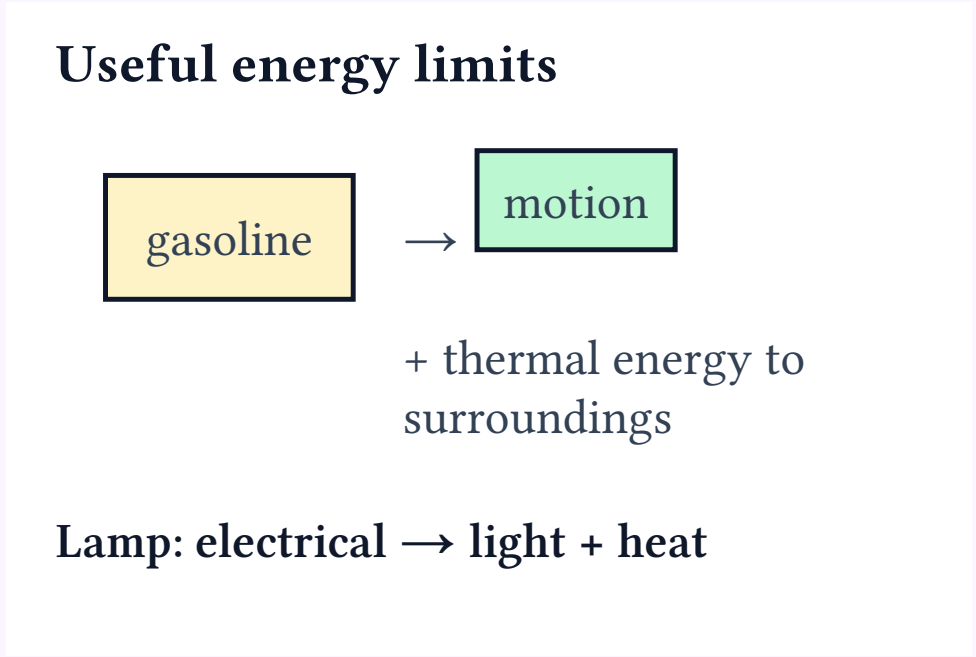
- A car, a refrigerator, a heat pump, and a food chain all move energy, and none of them is pure useful output.
- The first law is a balance of energy in and energy out. The second law says real transfers leave some energy less useful.



ıd law: some energy always spreads to surroundings as thermal eı

Useful energy limits

- The chemical energy in gasoline becomes the car's motion and thermal energy dumped to the surroundings.
- A lamp turns electrical energy into visible light and into thermal energy you can feel at the bulb.



Accounting for 100 joules

- Divide a 100 J input among useful output and thermal or sound transfers, then check the total.
- A complete answer makes the outputs add up to the input and explains the second law without saying the energy vanished.

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Unit B: Energy flow in technological systems

Efficiency and Alberta energy systems

Energy losses in a device

- A device receives 100 J and delivers 35 J as useful output.
- Its efficiency is 35%; the remaining 65 J is transferred in other forms, often thermal energy.



Useful and wasted output

- Report efficiency as a ratio and as a percentage.
- Then name the evidence you used to judge whether that system is a good choice here.

efficiency = useful out ÷ total in × 100%

Coal plant: ~35%	Gas combined-cycle: ~50%
Hydro: ~90%	Wind: ~40 to 50%

Approximate values vary by design and operating conditions

Key terms

efficiency

Useful energy output divided by total energy input, multiplied by 100%.

useful output

The energy output that serves the intended purpose.

energy input

The total energy supplied to a system.

system boundary

The chosen limit that determines which inputs and outputs are counted.

Efficiency

- Efficiency is the useful output divided by the total energy input.
- Use that ratio when you compare a heat pump, a furnace, and an engine.
- Say which output you counted as useful before you compare the percentages.

efficiency = useful out ÷ total in × 100%

Coal plant: ~35%	Gas combined-cycle: ~50%
Hydro: ~90%	Wind: ~40 to 50%

Approximate values vary by design and operating conditions

Alberta context

- Compare fuels for thermal plants on cost, what you gain, efficiency, and whether the supply can last.
- First Nations, Métis and Inuit perspectives on judicious use of resources.
- Name the system boundary before you treat two efficiency numbers as a fair comparison.

efficiency = useful out ÷ total in × 100%

Coal plant: ~35%	Gas combined-cycle: ~50%
Hydro: ~90%	Wind: ~40 to 50%

Approximate values vary by design and operating conditions

Efficiency and decision

- Calculate one efficiency and name one additional criterion needed for a technology decision.
- A complete answer gives the ratio and the percentage, then names one more piece of evidence for the decision.

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