Energy transfer technologies slide deck

Science 14

Unit B: Energy transfer technologies

Heat moves from the hotter object

Heat from refrigerator coils

- The food inside a fridge gets colder while the coils on the back feel warm.
- Those coils are dumping heat into the warmer kitchen air.

Heat and temperature

- Heat is energy moving from a hotter object to a cooler one.
- Temperature tells you how hot the object is, which tracks particle motion.

Key terms

heat

Thermal energy transferred from a hotter object to a colder object.

conduction

Heat transfer through a material by particles passing motion to their neighbours, strongest in metals.

convection

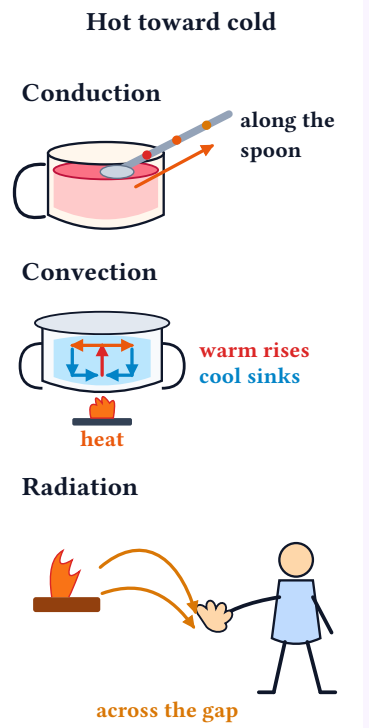
Heat transfer by the movement of a warmed fluid, such as air or water.

radiation

Heat transfer by infrared waves, which can cross empty space from a hot surface.

Three paths, one direction

- Conduction carries heat through a spoon left in a hot drink.
- Convection carries heat as warm air or water rises and cooler fluid sinks.



Fridge coils

- The food inside gets colder.
- The coils on the back pass that heat into the kitchen air.

A metal spoon

- The spoon handle warms by conduction from the hot drink.
- The drink is the hotter object and the handle starts cooler.

Radiant heat from a fire

- Radiation carries heat across the space between the fire and your face.
- The fire is hotter, so the heat moves toward you.

Hot and cold ends

- Every cooling device in this unit has a place where heat leaves and a place where heat arrives.
- The next lesson ties that transfer to particle motion and to local winds.

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Convection and climate

A dye spiral in a convection tank

- Warm water rises from a heater and cooler water sinks to take its place.
- A drop of dye draws that loop so the current can be seen.

Particle speed and convection

- A higher temperature means the particles move faster on average.
- Convection is a current: warm fluid rises and cooler fluid sinks.

Key terms

temperature

A measure of the average motion energy of the particles in a sample.

thermal energy

The total energy of the random particle motion in a sample.

Brownian motion

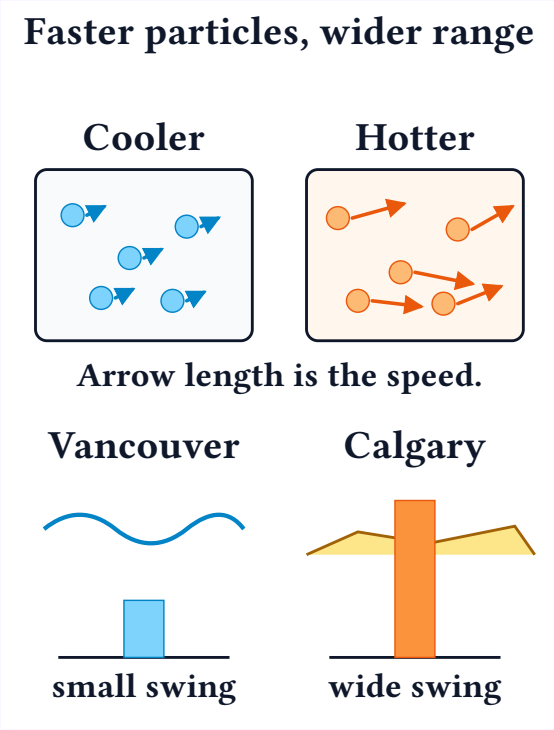
The visible jitter of tiny grains as invisible particles collide with them.

moderating influence

The effect of a large body of water that keeps nearby air from swinging to extreme temperatures.

Convection currents and coastal climate

- Higher temperature means a higher average speed of the particles.
- Vancouver's ocean keeps seasonal temperatures milder than Calgary's prairie air.



Dye in a tank

- Warm water rises from the heater.
- The dye draws the loop as cooler water sinks.

A metal bench in January

- Metal particles pass heat quickly to your hand.
- The bench and the air can share a temperature while the metal feels colder.

Vancouver and Calgary

- Vancouver has a large body of water nearby, so seasons stay milder.
- Calgary's prairie air allows a wider temperature swing.

Convection loops and cities

- A dye loop and a coastline loop are the same convection idea at two sizes.
- Vancouver and Calgary make the water-moderation comparison concrete.

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Insulation and thermal protection

Heat loss through a window

- A jacket traps air so body heat reaches the winter air more slowly.
- A single pane lets room heat reach the outdoors faster than a double pane.

Insulation and protection

- Insulation slows heat leaving a warm place, as a jacket traps air.
- Protective gear blocks a dangerous heat transfer, as a firefighter’s coat does.

Key terms

insulation

A material or gap that slows conduction, convection or radiation so heat transfer falls.

double glazing

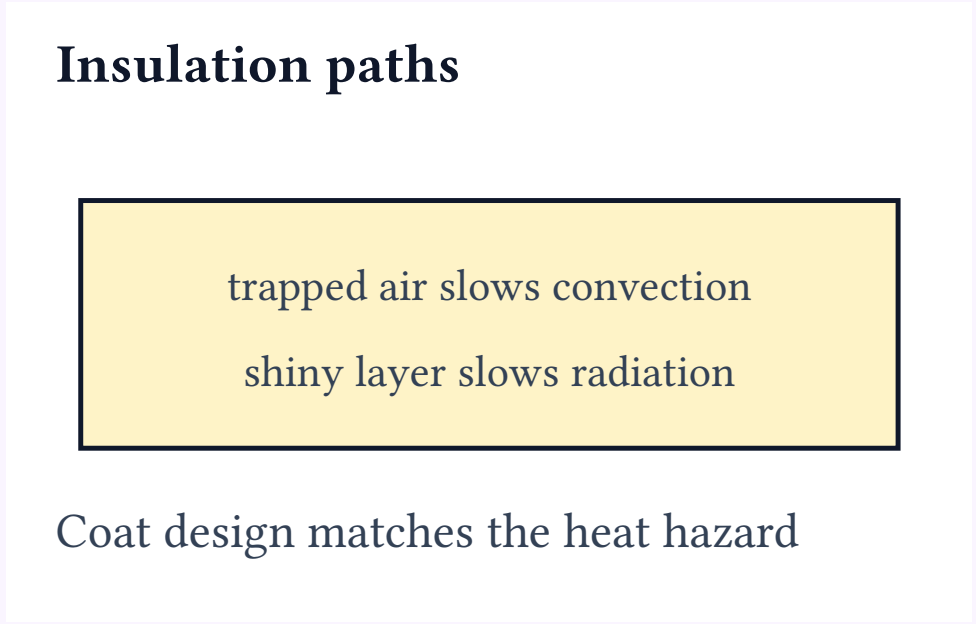
Two panes with a trapped gap, used so conduction and convection through a window slow down.

protective clothing

Gear that keeps a dangerous heat flow away from skin, such as a firefighter's layers.

Insulation and heat transfer paths

- Trapped air slows convection, and a shiny layer slows radiation.
- A firefighter's coat is built for extreme heat. A winter jacket is built for a cold walk.



Double glazing

- Two panes with a gap slow the heat leaving a room.
- The trapped air is the barrier in that gap.

A shiny layer

- A shiny layer sends radiation back.
- Trapped air slows the convection path.

Bottle test

- The bottle whose temperature rises slowest has the stronger insulator.
- Rank the materials from that temperature record.

Insulation test graph

- The slowest temperature rise marks the stronger insulator in your bottle test.
- House upgrades and safety gear are two uses of that ranking.

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Why water changes temperature slowly

Water and oil heating rates

- Equal masses of water and cooking oil receive the same heating time.
- The oil’s temperature climbs faster than the water’s.

Specific heat capacity

- Water takes in a lot of heat for each degree its temperature rises.
- Cooking oil changes temperature faster under the same heat.

Key terms

specific heat capacity

The heat a stated mass of a substance absorbs or releases for each degree of temperature change.

controlled variable

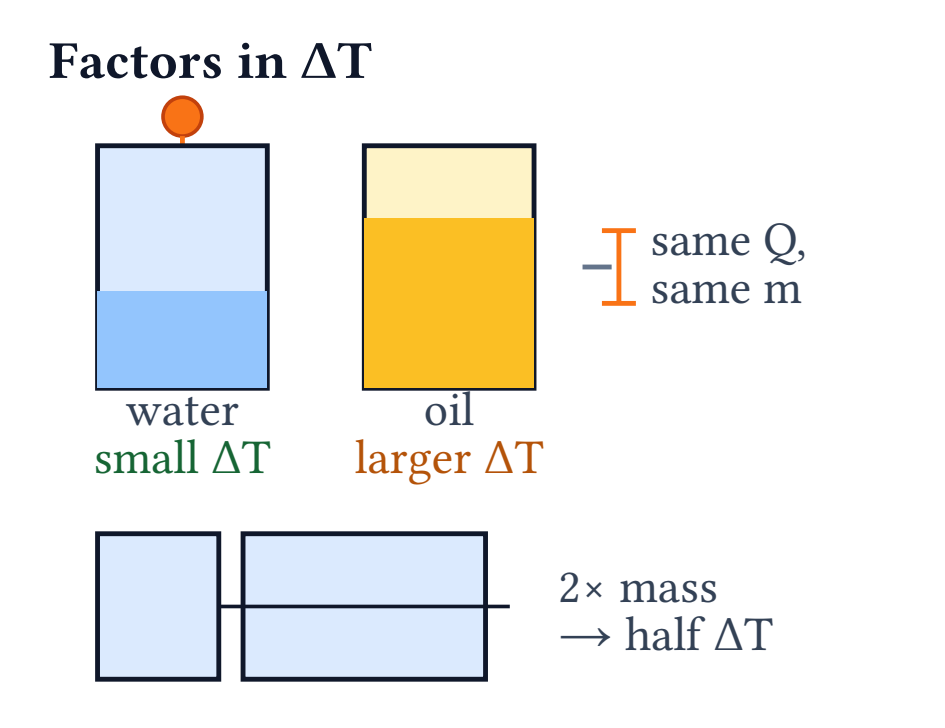
A factor you keep the same so the comparison is fair, such as starting temperature or heater setting.

manipulated variable

The factor you deliberately change, such as the type of liquid or the mass.

Factors in temperature change

- A high specific heat capacity means a smaller temperature change for the same heat and mass.
- Doubling the mass, with the same heat, cuts the temperature change for that material.



Oil and water, same heat

- The oil rises about 12 degrees and the water rises about 5.
- Water has the higher specific heat capacity in that test.

Same heat, different climb

- The heater setting and the time stay the same.
- The larger temperature climb belongs to the lower specific heat capacity.

A heavier pot of water

- The same heat spread through more mass gives a smaller temperature change.
- Material and mass both belong in the comparison.

The manipulated variable

- Material in one trial, mass in the next, and the heater stays the controlled variable.
- The lake and the kettle are the same specific-heat story at two sizes.

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Simple machines and work

A crowbar lifts a stuck board

- A long crowbar lets a small push on the handle produce a larger push on the board.
- Your hand travels farther than the board moves.

Work and the fulcrum

- Work is the force times the distance, and the unit is the joule.
- A fulcrum is the pivot on a lever, between the input force and the output force.

Key terms

work

Energy transferred when a force moves an object in the direction of the force. (W = Fd)

joule

The SI unit of work and energy. One joule equals one newton metre. (J)

newton

The SI unit of force. (N)

fulcrum

The pivot or turning point of a simple machine, such as the hinge of a lever or the axle of a doorknob.

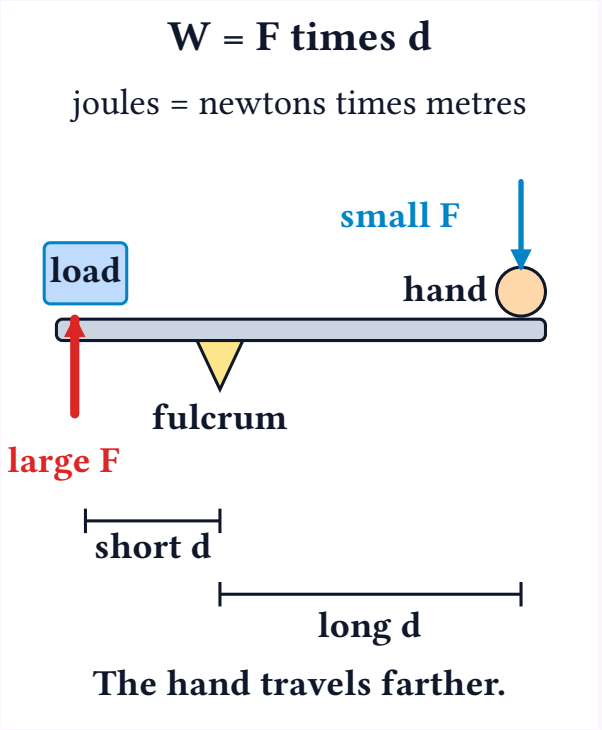
Key terms

force multiplier

A machine whose output force is larger than the input force, while the input moves farther than the load.

Work and mechanical advantage

- Work in joules is the force in newtons multiplied by the distance in metres.
- A lever can push harder than your hand, and your hand moves farther to do it.



30 newtons through 4 metres

- Multiply the force by the distance: 30 times 4.0.
- The work is 120 joules.

A small push on a crowbar

- The hand travels farther than the board moves.
- The board receives a larger force than the hand applied.

A teeter-totter

- A heavier rider sits closer to the fulcrum.
- A lighter rider sits farther out so the board can balance.

Force and distance on a lever

- The teeter-totter shows the force-and-distance balance with two masses.
- A crowbar, a pair of scissors, and a car jack each have an input, an output, and a fulcrum.

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Efficient machines and renewable sources

A solar cooker and a hand-wound radio

- A solar cooker sends sunlight into a pot and some of that energy warms the food.
- A hand-wound radio turns muscle work into sound and also into wasted heat in the gears.

Efficiency and renewable energy

- Efficiency compares the useful output with the total energy you put in.
- Sunlight and wind are renewable because they can supply energy again in a person's lifetime.

Key terms

efficiency

The fraction of the energy input that becomes useful output in a device.

renewable energy source

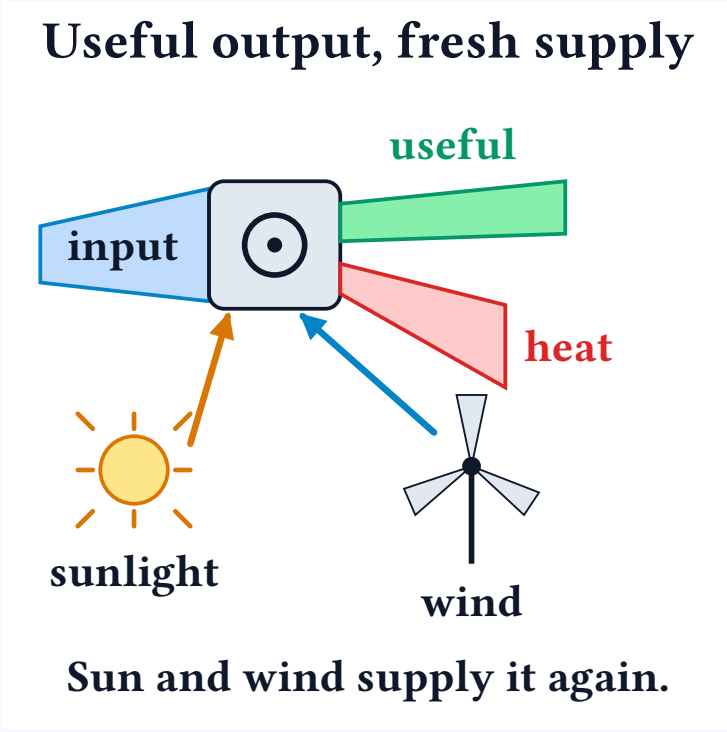
A source that is replenished on a human timescale, such as sunlight or wind.

nonrenewable energy source

A source that is used far faster than Earth replaces it, such as coal, oil or natural gas.

Useful output over input, then the source

- A machine does better when more of the energy you put in becomes the job you wanted.
- Sunlight and wind can supply that energy again within a person's lifetime.



A solar cooker

- Sunlight goes in and hot food is the useful output.
- Some of the energy also leaves as thermal energy around the pot.



A hand-wound radio

- Muscle work goes in.
- Sound is the useful output, and the gears also warm up.

A week of meter readings

- Cooking, hot water, and laundry make the daily peaks.
- A more efficient appliance lowers the energy those jobs use.

A peer unit check

- Name the input, the useful output, the energy source, and one change that would waste less.
- Meter readings over a week show when the household demand peaks.

Image credits

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