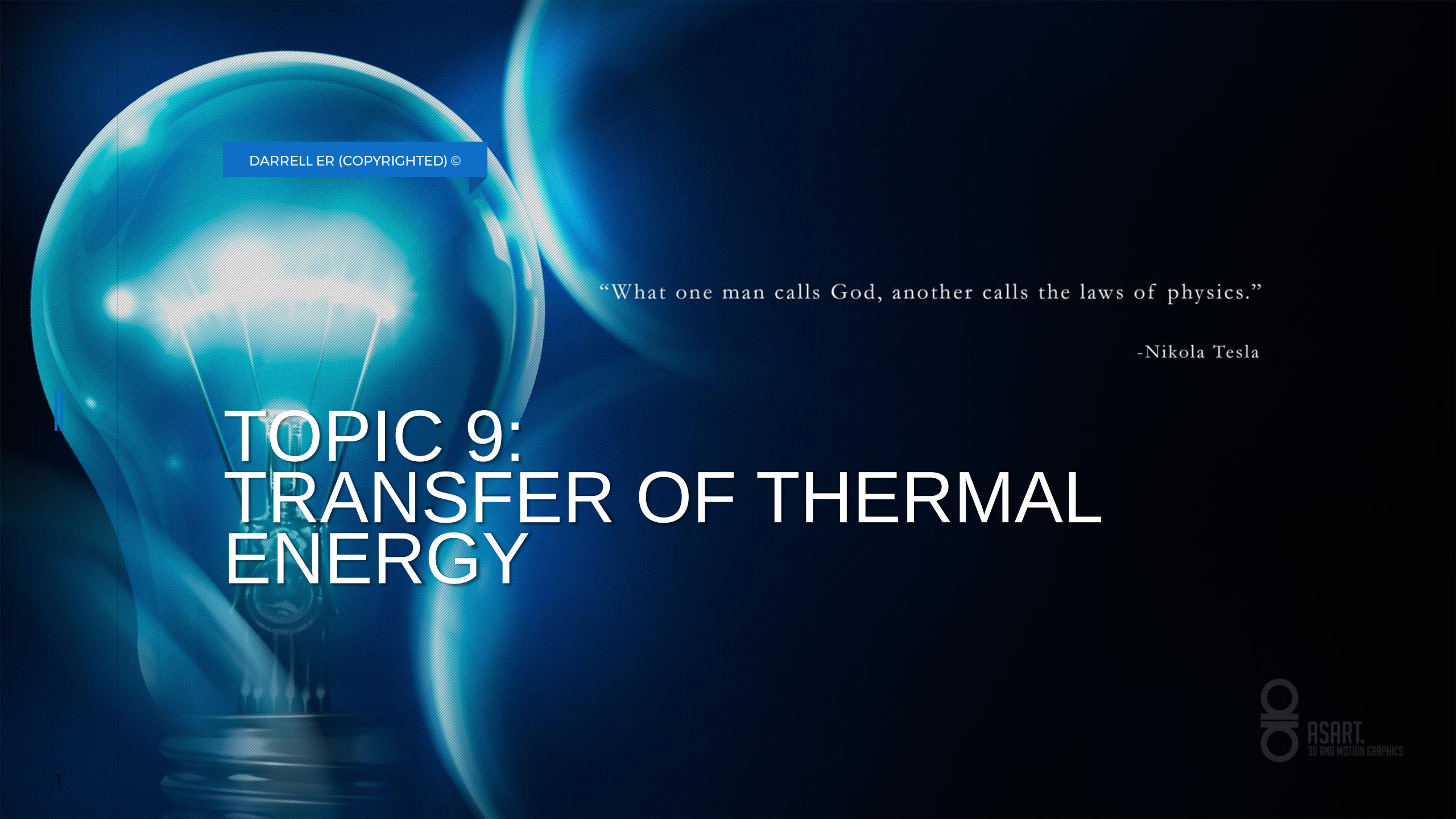


"What one man calls God, another calls the laws of physics."

-Nikola Tesla

TOPIC 9: TRANSFER OF THERMAL ENERGY

THE ABOUT

CHAPTER ANALYSIS

TIME

- Simple topic
- 3 **key** concepts
- Conduction, Convection, Radiation

EXAM

- Tested quite often
- Require drawing of convection currents quite often
- Need to understand application of each thermal transfer

WEIGHTAGE

- Light-medium overall weightage
- Constitute to around **4%** of marks for past 5 year papers

KEY CONCEPT

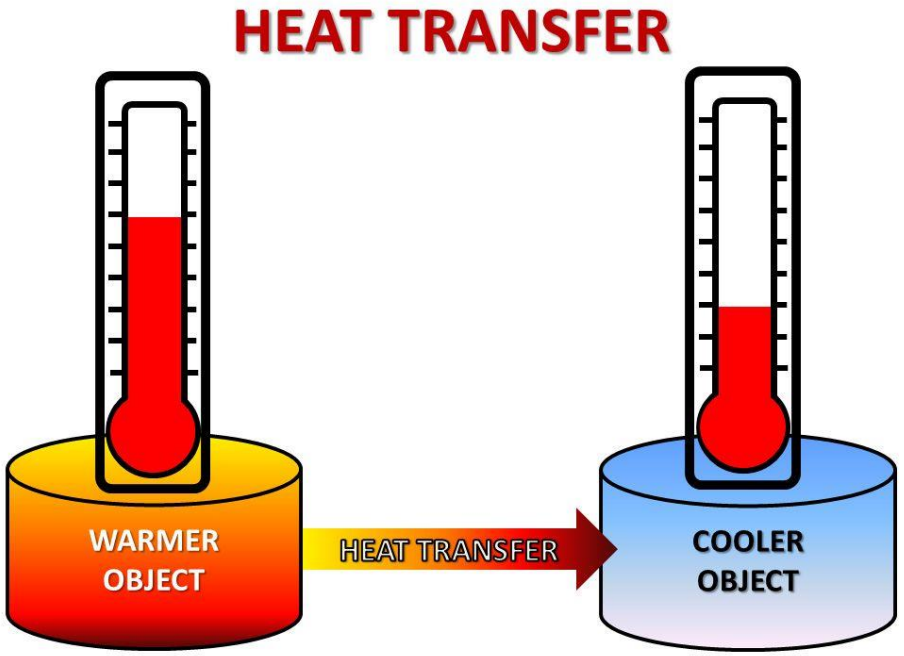
TRANSFER OF THERMAL ENERGY

CONDUCTION

CONVECTION

RADIATION

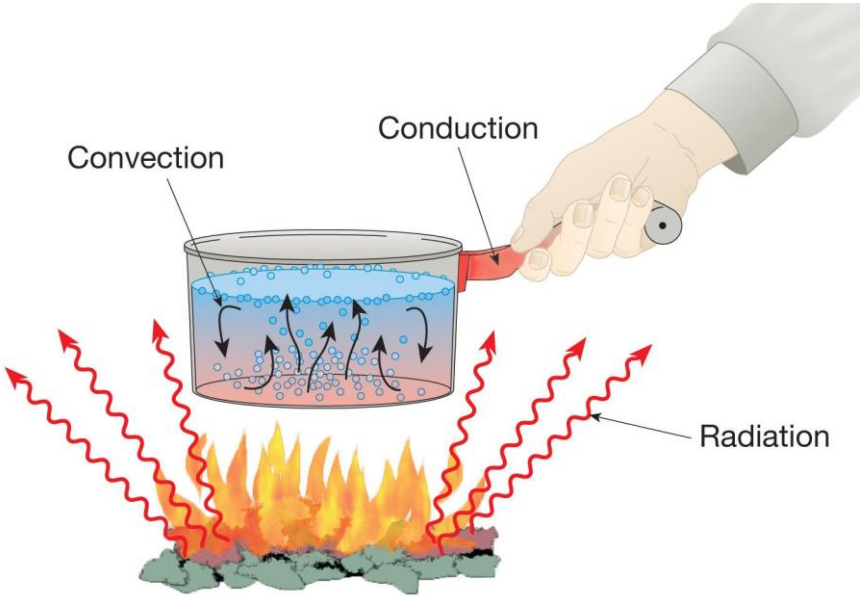
LAW OF THERMAL ENERGY



LAW OF THERMAL ENERGY

- Thermal energy flows from a region of **higher temperature** to a region of **lower temperature**

- Can be transferred through **conduction, convection** or **radiation**



*Do not use *'heat energy'*.

CONDUCTION

CONDUCTION

Conduction is the process by which thermal energy is transmitted through a medium from one particle to another.

There is no net movement of atoms during the process of conduction. Thermal energy is transferred through the increase in vibrational kinetic energies of the atoms.

SOLID, LIQUID, GAS

Solids are better conductors of thermal energy than liquids and gases.

Molecules are **packed closer together in solids** than in liquids and gases, thus kinetic energy can be transferred more quickly.

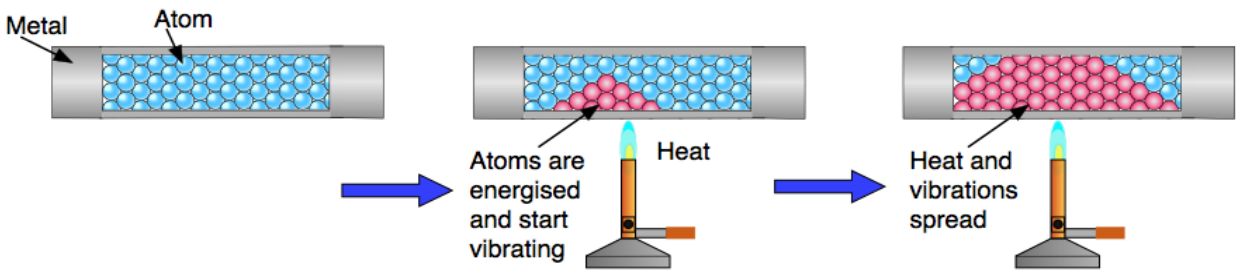
CONDUCTORS

- Cooking utensils
- Heat sinks in electronic equipment conduct thermal energy away to avoid overheating

INSULATORS

- Wooden ladle used to stir hot things
- Kettles, saucepans and electric irons have plastic or wooden handles

Conduction in solid



When one part of the solid is heated, the **atoms there gain kinetic energy and vibrate faster**.

These atoms **collide** with their **less energetic neighbours**, resulting in **a transfer of kinetic energy from the hotter area to the colder area**.

This process continues until all the particles possess the same amount of thermal energy.

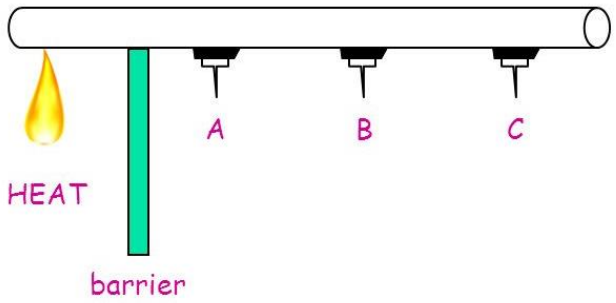
Conduction in metals

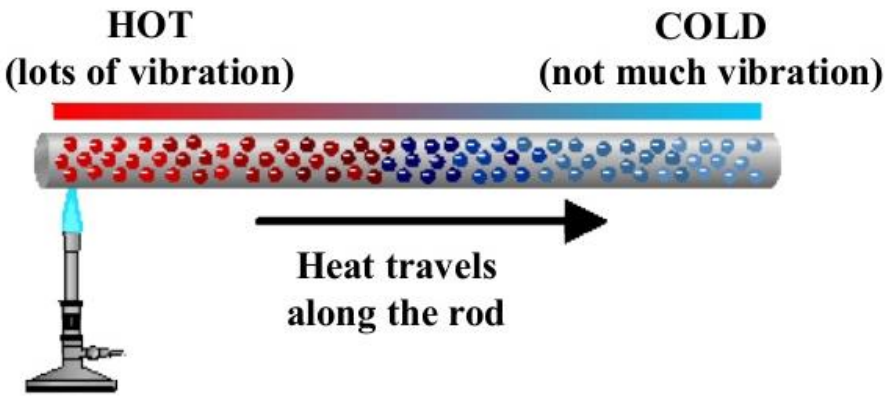
Conduction is **far better in metals** than non-metals due collision of vibrating atoms & the movement of free electrons.

When heated, the **free mobile electrons** gain energy and move faster. Since free electrons are free to travel in the spaces between the atoms to transfer energy, conduction occurs much faster in metals.

CANDLE WAX EXPERIMENT

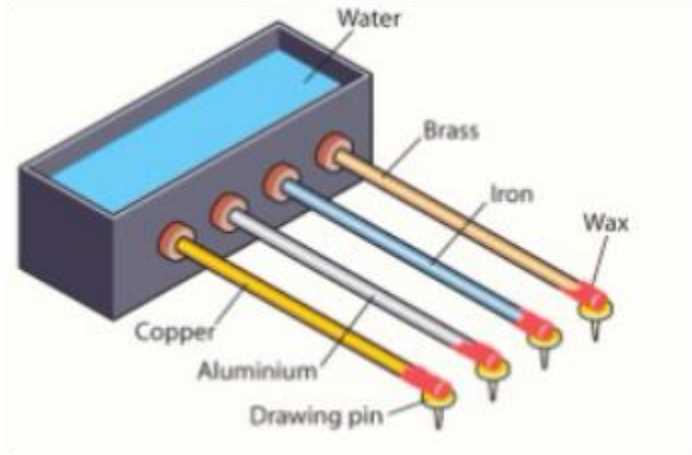
Experiment





As heat energy is transfer from the hotter end of the rod to the other end through conduction, the nail at A will drop off first, followed by B then lastly, C.

ANOTHER EXPERIMENT:



We can also observe the rate of conduction across different materials through this experiment too!

CONVECTION

CONVECTION

Convection is the process by which thermal energy is transmitted from one place to another by the movement of heated particles in a fluid. (gas or liquid)

LIQUID, GAS

Convection in gases occurs much more readily than in liquids.

Gases expand much more than liquids when temperature rises.

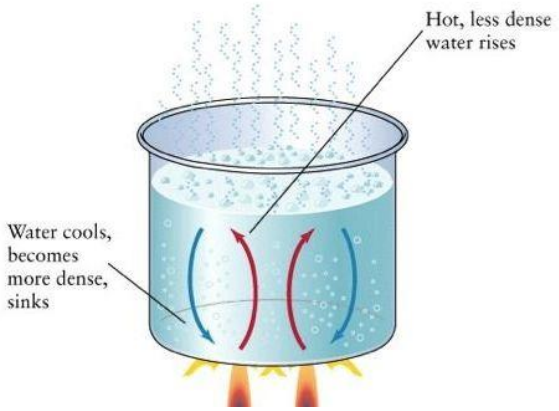
APPLICATION

- **Air conditioners** are best placed near the ceiling of a room as **cool air blown sinks** as it is denser than the warm air in the room. Warm air rises and is drawn into the air conditioner where it is cooled and release thereafter.

- **Freezer compartment** is usually found near the **top part of a refrigerator** as cold air below the freezer compartment sinks. This sets up a convection current which cools all the food effectively in the refrigerator.

- **Sea and land breezes** are natural convection currents.

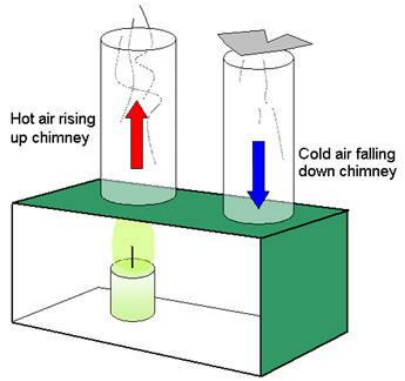
Convection in liquid



When part of a liquid is heated, it expands in volume, becoming less dense than the surrounding liquid and rises.

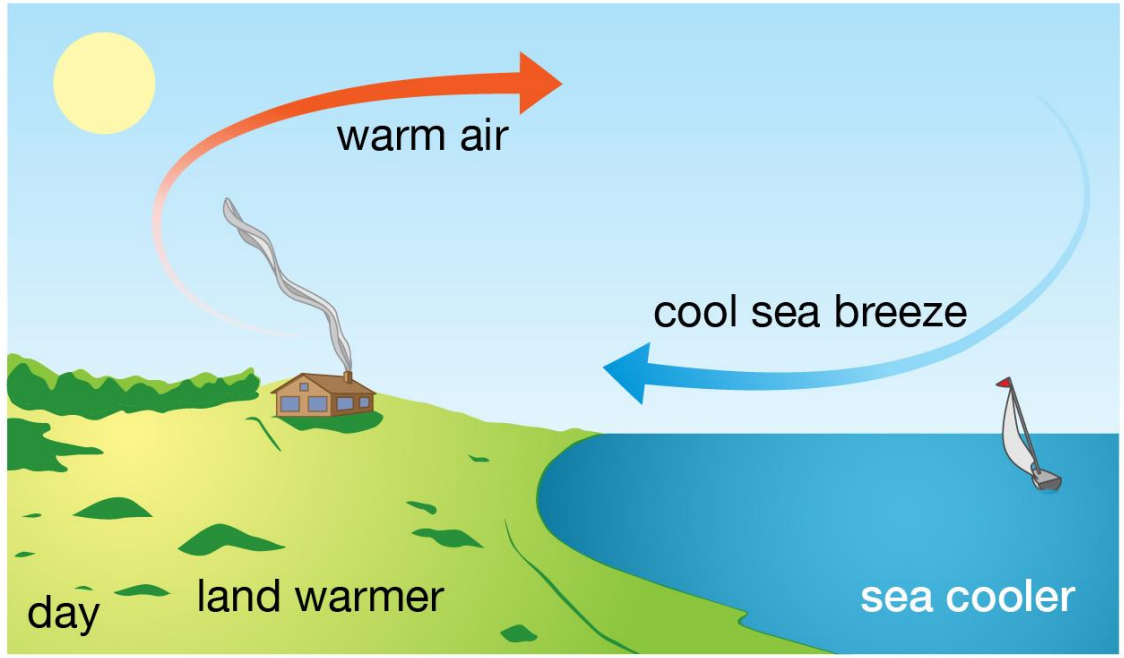
The cooler and denser liquid sinks. The cooler liquid in turn gets heated up and rises, resulting in a continuous convection current.

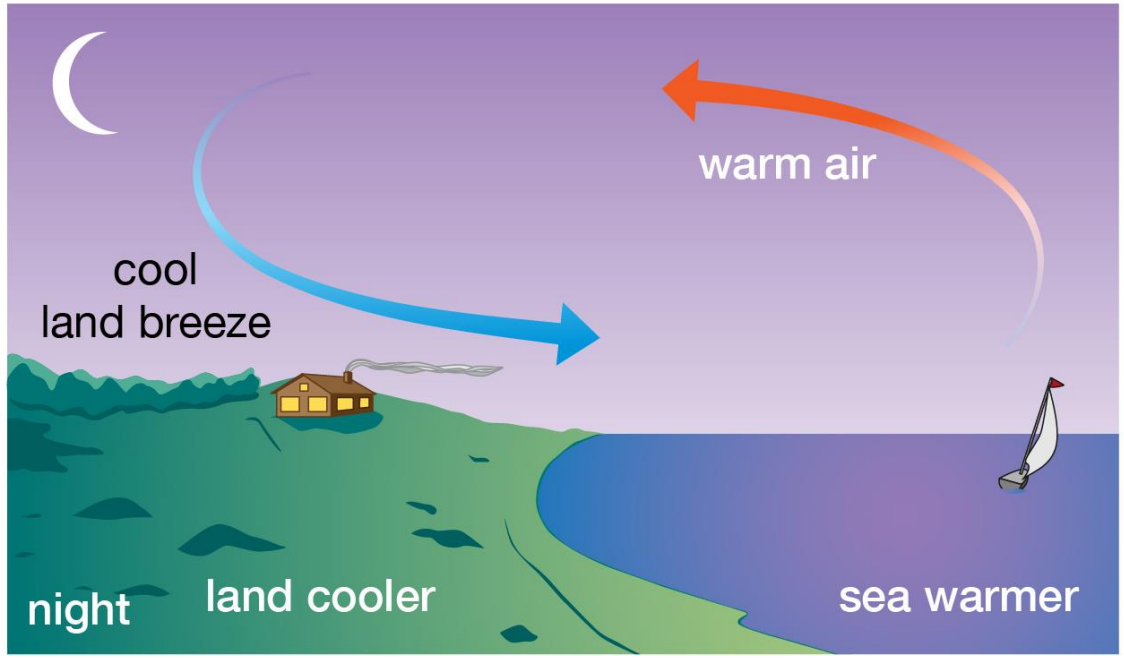
Convection in gas



The hot air near the heat source rises as it expands and becomes less dense, while the cooler and denser air at the top sinks.

The cooler air now gets heated up and rises, resulting in a continuous convection current.





SEA BREEZE & LAND BREEZE

As land consists more solid mass while the sea is mainly water, the **land gains and loses heat faster.**

In the day, the land heats up faster and the air above it rises. The cooler air above the sea is denser and sinks. This results in a convection current being formed where the wind is blowing towards the shore. This is known as sea breeze.

At night, the sea loses heat slower and the air above it is rises. The land cools down faster and the air cools down and the denser air sinks. A convection current is formed and wind is blowing towards the sea. This is known as land breeze.

So for little lovebirds going to the beach at night to enjoy the "sea breeze", please don't embarrass yourself. It's land breeze yea!

RADIATION

RADIATION

Radiation is the process by which thermal energy is transferred by electromagnetic waves. (infrared radiation)

NO MEDIUM REQUIRED

Does not require any medium (can take place in a vacuum).

APPLICATION

- Shiny metal teapot is a poor emitter of infrared radiation, keeping the liquid hot.

- Cooling fins and heat sinks of electronic equipment are painted dull black to emit infrared radiation quickly.

- Thermal blankets are bright, have shiny outer surface that emits infrared radiation at a slower rate.

- Factory roofs are sometimes coated with aluminium paint to reduce absorption of infrared radiation during the day and emission of infrared radiation during the night. This helps to maintain a fairly steady temperature within the factory.

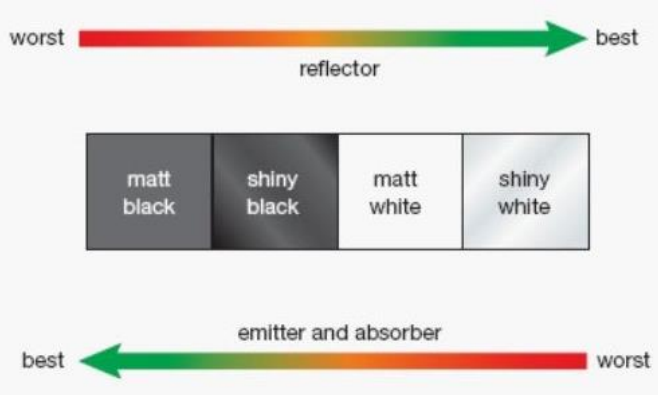
- Solar panels painted dull black to absorb as much infrared radiation from the sun as possible.

FACTORS AFFECTING RADIATION

- Surface temperature
  (The hotter an object, the higher the rate of energy emission.)

- Surface area
  (The larger the surface area, the higher the rate of energy transfer.)

- Surface colour & temperature
  (Rough, dull black surface is a better emitter and absorber of infrared radiation.)



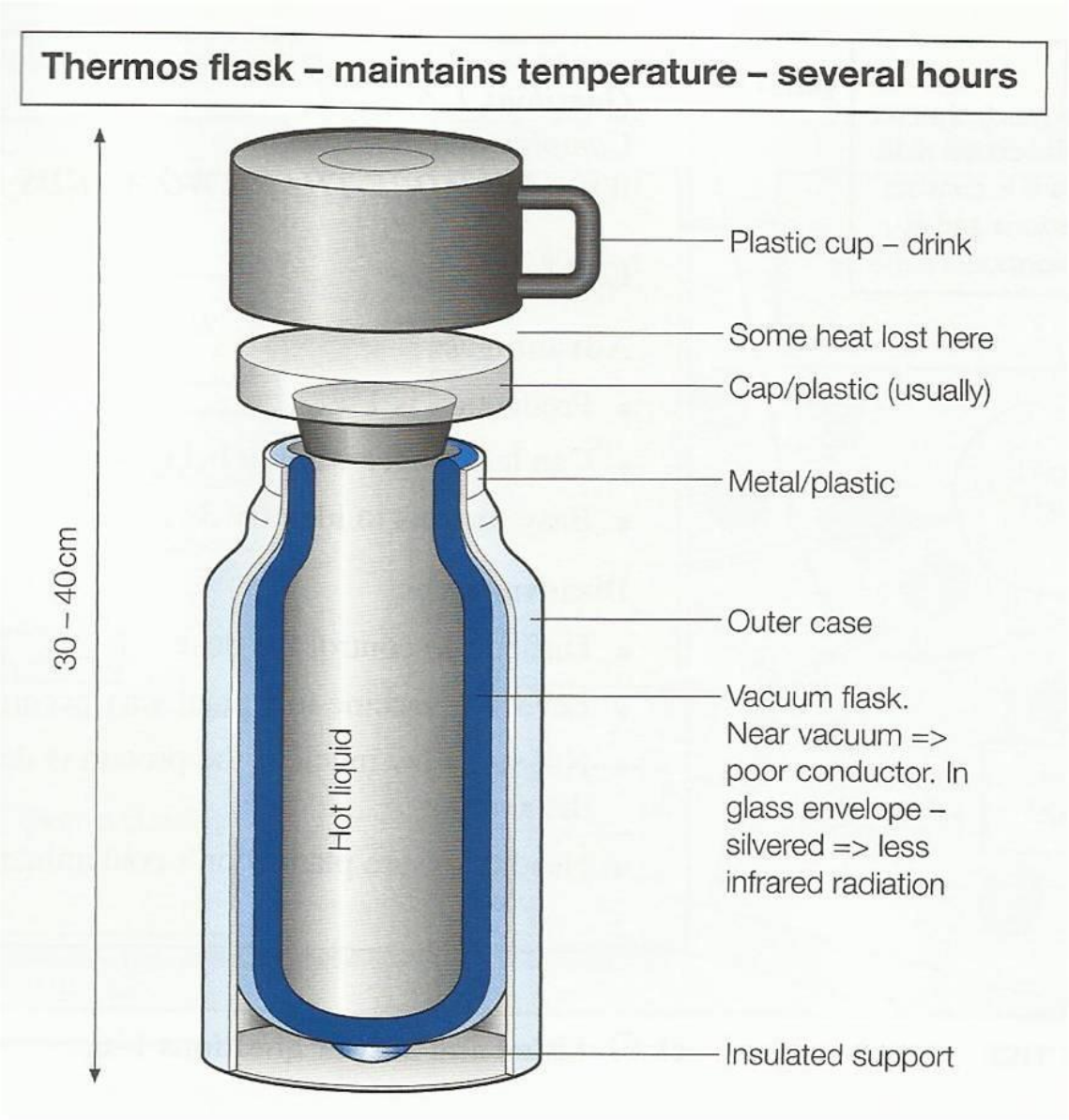
Sun & Earth

Radiation is the means by which energy reaches us from the sun.

There is a vacuum between the earth and the sun, meaning conduction and convection cannot take place.

Sun's energy travels to the earth in the form of **electromagnetic waves*** at the speed of light.

**to learn more under chapter 'Electromagnetic Waves".*



VACUUM FLASK

Designed to keep hot liquids hot and cold liquids cold.

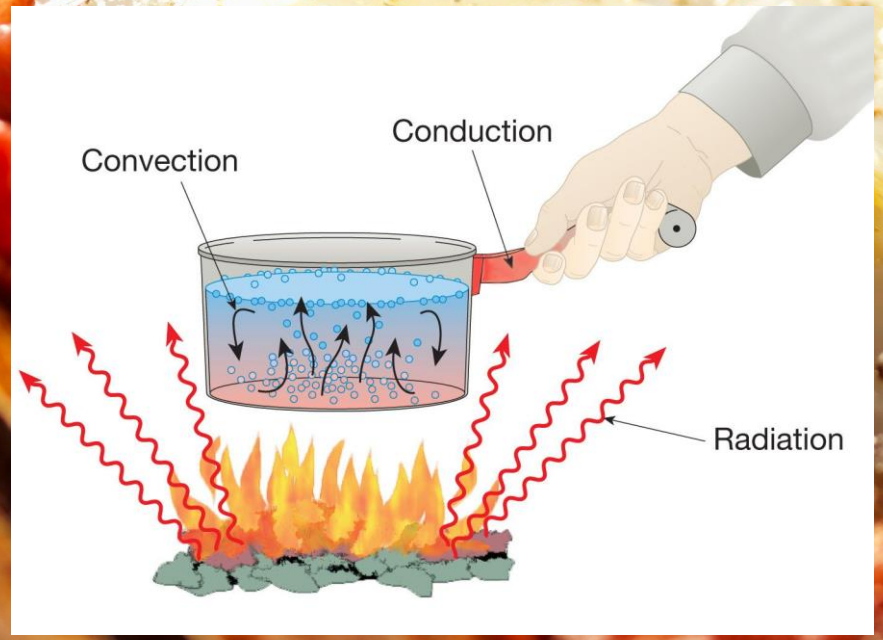
Features:

Double-walled glass container, with a **vacuum** between the walls
→ prevents thermal energy transfer by conduction and convection

Silvered surfaces on the inside and outside of the flask
→ poor absorbers and emitters of thermal energy
→ reflects infrared radiation from hot fluids back into the flask
→ reflects infrared radiation from external surroundings away from a cool flask

Plastic cap prevents heat loss through convection and evaporation

SUMMARY TABLE



All 3 processes can occur simultaneously!

Conduction	Convection	Radiation
Conduction is the process by which thermal energy is transmitted through a **medium from one particle to another**.	Convection is the process by which thermal energy is transmitted from one place to another by the **movement of heated particles in a fluid**. (gas or liquid)	Radiation is the process by which thermal energy is transferred by **electromagnetic waves.** (infrared radiation)
Occurs in solid, liquid & gas	Occurs in liquid & gas (fluids)	Does not require a medium
Conduction is faster in: Solid > Liquid > Gas	Convection is faster in: Gas > Liquid	Factors: - Surface temperature - Surface area - - Surface colour & texture

For all the koreaboos out there,

You will be familiar with ramen pot. But have you wondered about the physics behind it?

1) The material is made of nickel-silver plated aluminum. It heats up very quickly which makes the cooking process faster as water can boil quicker. (conduction)

2) The lid is also there to reduce heat loss through convection. This helps the noodles to cook faster! (convection)

3) The shiny surface reduces heat loss through radiation, keeping the noodles warm for a longer period of time! (radiation)

Sorry if I made you hungry haha~

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