HEAT FLOW

PES 1000 – PHYSICS IN EVERYDAY LIFE

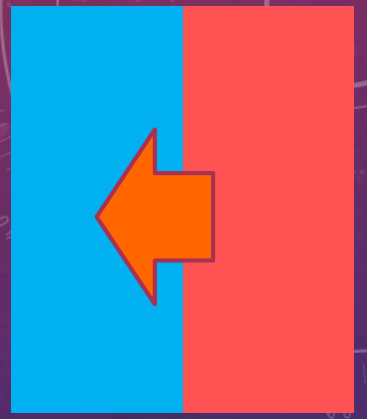
HEAT IS A TRANSFER OF THERMAL ENERGY

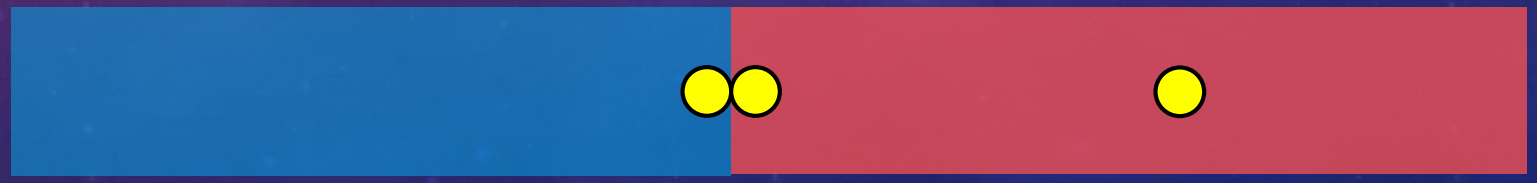
- We know from experience that ‘hot’ objects tend to get cooler and ‘cold’ objects tend to get hotter.
- This is because heat naturally flows from a hot object and heat naturally flows to a cold object.
- There are three ways that heat can flow:
  - Conduction – Direct contact transfers heat between objects at different temperatures.
  - Convection – A fluid (liquid or gas) transfers heat between objects at different temperatures.
  - Radiation – Electro-magnetic radiation transfers heat from an object to its environment.
- Following are some details and examples of these three heat transfer methods.
- If we want to prevent heat transfer (to design a thermos, perhaps), we’ll need to eliminate or minimize each of the three types of heat flow.

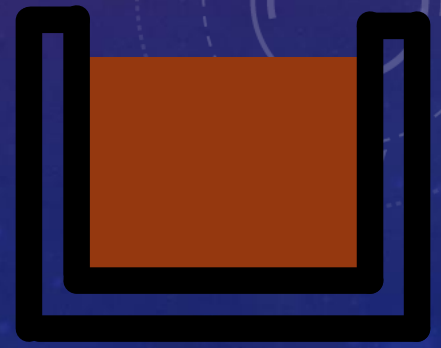
CONDUCTION

Conduction – Direct contact transfers heat between objects at different temperatures.

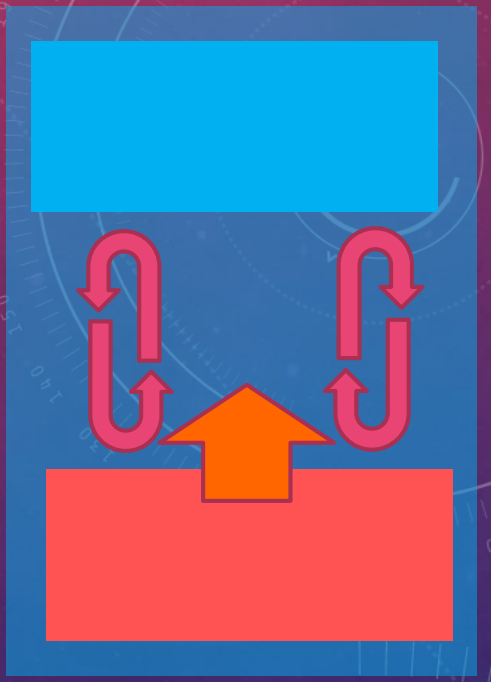
- Particles (atoms and molecules) at the borders exchange motional energy
- More particles transfer their energy from the hot side to the cold side than the other way around.
- On average, kinetic energy is transferred (as heat) from ‘hot’ to ‘cold’.
- To keep coffee hot, you could have a double-walled container to isolate the hot liquid from the cold air outside.







CONVECTION



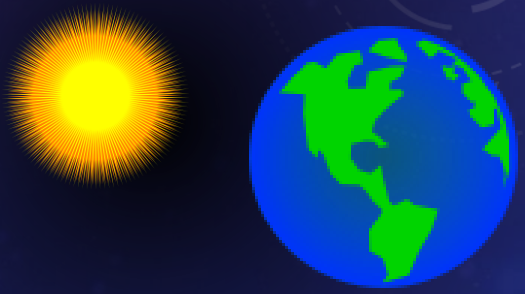
Convection – A fluid (liquid or gas) transfers heat from hot to cold objects.

- Heat flows from the hot object to the fluid, increasing its temperature.
- The fluid moves toward the cold object
  - It may be forced toward the cold object by pumping it.
  - It may move toward the cold object on its own. Hot fluids are less dense, so they rise through the colder layers of the fluid.
- The hot fluid transfers its thermal energy to the cold object, becoming cooler itself.
- The fluid is moved or sinks back toward the hot object, and the cycle starts again.
- If the hot object is at the bottom of a fluid, convection currents will be established. These currents circulate heat between hot and cold.
- The cold object could be the cold air above a boiling pan of water, and the hot object is the bottom of the heated pan.

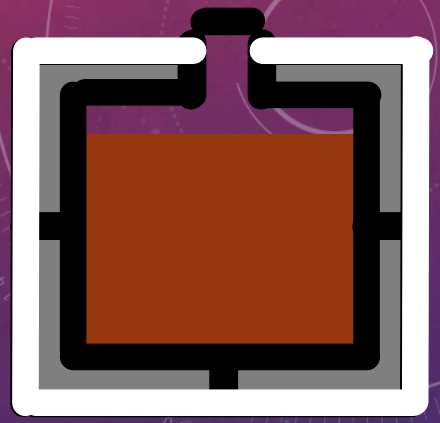
RADIATION

Radiation – Electro-magnetic radiation transfers heat from an object to its environment.

- A hot object will transfer heat to a colder environment, even if there is no direct contact or a fluid to transfer heat.
- Electro-magnetic radiation (Visible light, infra-red light, etc.) is a form of energy, so it carries energy away from the hot object and transfers it to the cold environment.
- Heat flows by this method even through a perfect vacuum.
- This is good for us; without it, heat from the Sun wouldn't be able to reach Earth!

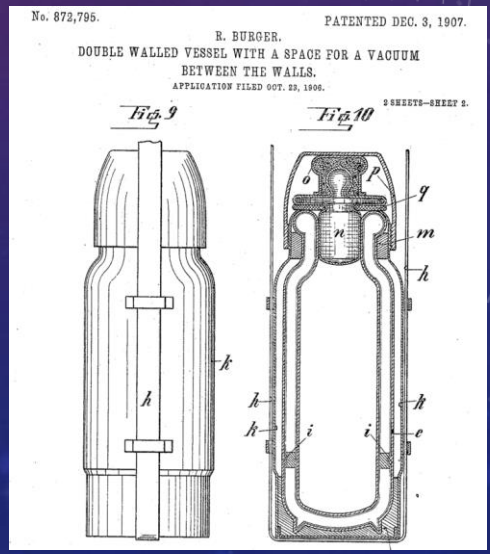


DESIGNING A THERMOS TO REDUCE HEAT FLOW



We would like to design a thermos to keep hot things hot or cold things cold. Let's imagine we want to keep coffee as hot as possible for as long as possible.

- Reduce conduction – It is impractical to completely isolate the coffee chamber from the atmosphere, but we can reduce direct contact with a double-walled container.
- Eliminate convection – We can remove the possibility of heat transfer by a fluid (air) from the inner chamber to the outer chamber by having a vacuum in the space between.
- Minimize radiation – Even with a perfect vacuum, we can't stop radiation transfer from the inner chamber to the outer chamber. But we can silver the inner walls of the outer chamber. This will reflect at least some of the radiation back to the inner chamber.
- Perfect isolation is impossible, so the coffee will eventually get to room temperature, but a good thermos will keep it hot for a very long time!


No. 872,795. PATENTED DEC. 3, 1907.

R. BURGER.

DOUBLE WALLED VESSEL WITH A SPACE FOR A VACUUM BETWEEN THE WALLS.

APPLICATION FILED OCT. 23, 1906. 2 SHEETS—SHEET 2.

Fig. 9 Fig. 10

CONCLUSION

- Heat flows from an object at a higher temperature to an objects at a lower temperature.
- There are three ways that heat can flow:
  - Conduction – Direct contact transfers heat between objects at different temperatures.
    - Reducing direct contact restricts this flow.
  - Convection – A fluid (liquid or gas) transfers heat between objects at different temperatures.
    - Eliminating any type of fluid will prevent this type of flow.
  - Radiation – Electro-magnetic radiation transfers heat from an object to its environment.
    - Reflection can reduce this type of flow.
- There is no such thing as a perfect heat insulator.