

Conduction, Convection and Radiation

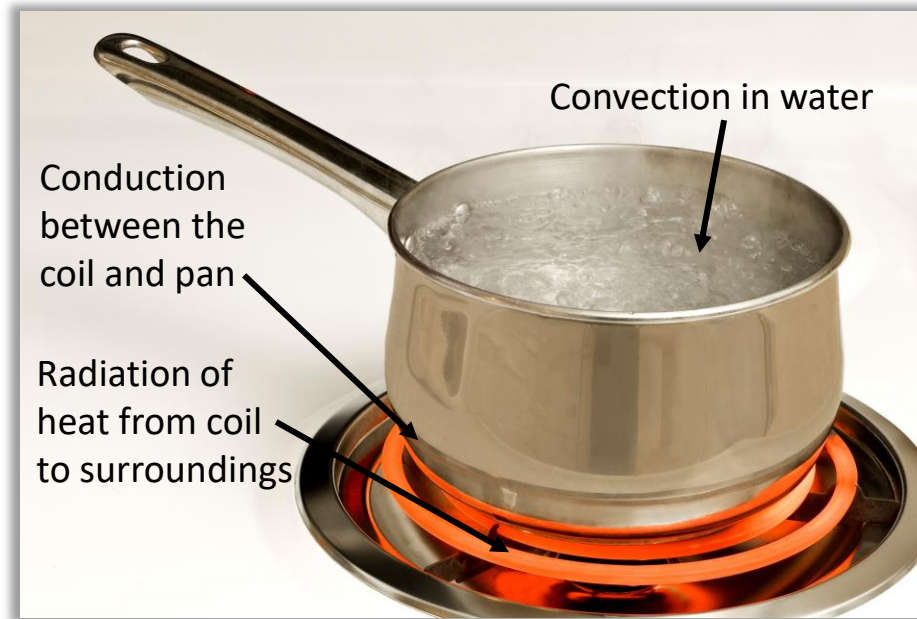
Heat Transfer Analysis – Lesson 2



/ How Does Heat Flow?

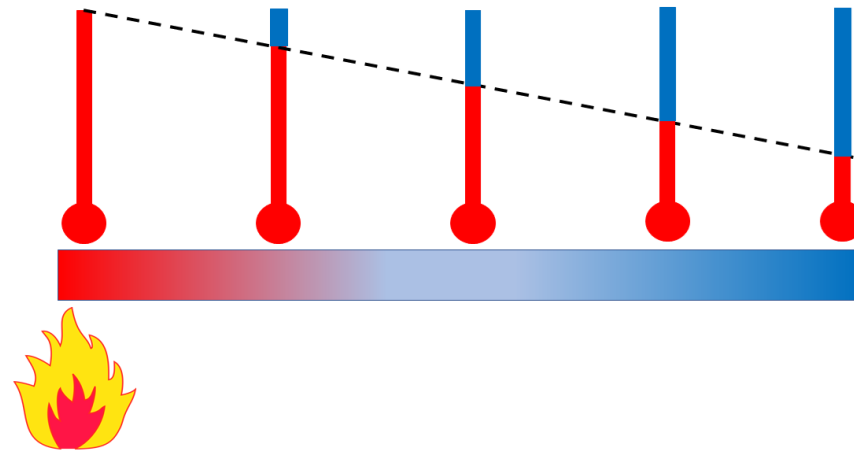
Heat flows from a hot body to a colder body in one of the three ways:

- **Conduction:** heat flow due to increased vibration of molecules
- **Convection:** heat flow due to movement of fluid molecules
- **Radiation:** heat flow through electromagnetic waves



Conduction

- In any material, at atomic scales, molecules are always vibrating with a specific amplitude.
- When heat is supplied to some molecules, they get excited and the amplitude of their vibration increases.
- The excited molecules collide with their neighbors, transferring some of their energy.
- The neighboring molecules become excited and collide with other neighboring molecules.
- Thus, heat energy gets transferred from the hotter to cooler part of the body.
- A thermal gradient (or difference in temperatures) is necessary for heat flow to occur.



Conduction in Real Life

We come across various examples of conduction in our daily lives. Conduction is the reason:

Ice cubes melt when removed from the freezer



Our hands feel warm when we hold a steaming, hot cup of coffee



Food cooks on a stove top

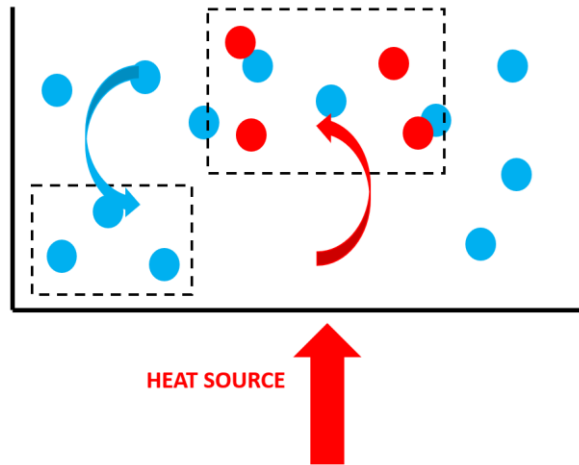


Different materials conduct heat at different rates (e.g., metal conducts heat faster than wood).



Convection

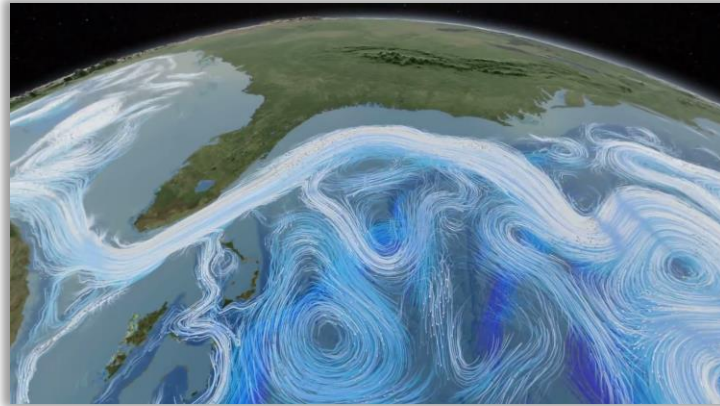
- In fluids (i.e., liquids and gases), heat transfer occurs due to movement (not just vibration) of the fluid molecules.
- When a fluid is heated, the volume of the fluid closest to the heat source increases and the density decreases. As a result, this fluid flows to the top, while colder/denser fluid from surrounding areas, takes its place. Then, the cold fluid gets heated and moves to the top.
- This sets up a current in the fluid that leads to the heating up of the entire fluid.
- This method of heat flow — caused by the movement of fluid molecules — is called convection.



The Omnipresent Effects of Convection

Convection affects various aspects of our daily lives and is widely used to control temperature in different applications:

Ocean currents that impact climate and local ecosystems are caused by convection.



Overheating may cause serious damage to our laptops and computers. To prevent this, fans are used to remove excess heat via convection.



Engines in cars and bikes have radiators that use fluid circulation (and convection) to prevent overheating.



When the wind blows in winter, we lose body heat due to convection. As a result, the temperature we experience is lower than the actual ambient temperature.



/ Radiation

- All matter with temperatures greater than absolute zero emit heat in the form of electromagnetic waves.
- These waves do not require a medium to propagate.
- Radiation is the transfer of heat energy in the form of electromagnetic waves.



Examples of Radiation

Radiation is how heat from the sun reaches the Earth (the space between the sun and the Earth is a vacuum, so conduction or convection isn't possible).



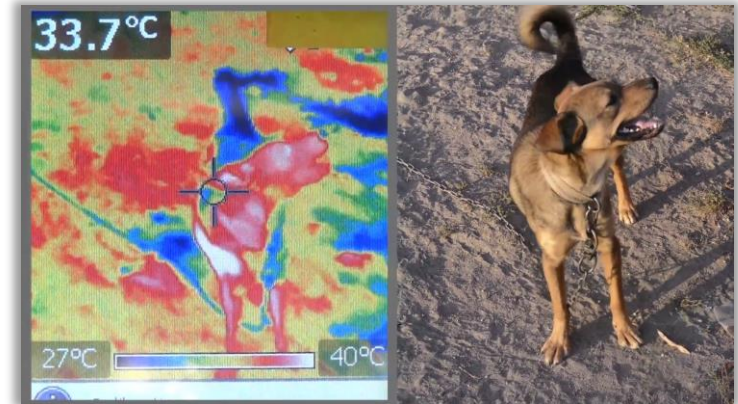
When we sit near a campfire, we are warmed through radiating heat.



Toaster ovens have heating coils which radiate heat and thus, toast the bread.



Since bodies at different temperatures radiate different amounts of heat, thermal imaging can be used to capture their shape/size. This is the working principle behind night vision goggles.



Ansys

