

Heat Transfer by Conduction, Convection, and Radiation

Heat is thermal energy that can be transferred from one place to another by conduction, convection and radiation. Conduction and convection involve particles, but radiation involves electromagnetic waves.

Conduction

Put a metal spoon in a pot on the stove and the handle gets hot. This is conduction – the handing-off of heat through a material.

Conduction is the way thermal energy transfers from one substance to another by direct contact. Kinetic energy is transferred as higher temperature vibrating molecules or atoms collide with cooler matter, increasing the kinetic energy of the cooler substance. Conduction can be direct contact between solids, or between a solid and a fluid.

Some materials conduct heat well, like the metal spoon. If you leave a wooden spoon in a pot of soup, the handle doesn't get hot. Materials that don't conduct heat well are called insulators. Ceramic, wood, plastic, foam, wool, and air are all good insulators. Insulators are good at helping to reduce conduction of heat toward or away from an object.

Convection

A wood stove warms the air around it, but it doesn't warm the whole house until you turn on a fan to circulate that warm air. This is called convection.

Convection occurs when moving fluids (gases or liquids) rise and fall due to differences in density caused by differences in thermal energy.

While conduction involves molecules passing their kinetic energy to other molecules, **convection** involves the molecules themselves moving from one place to another. For example, a fan works by displacing hot air with cold air. Convection usually takes place with gases traveling from one place to another.

Convection is part of the reason that wind makes you cold – heat flows away from your body more rapidly in wind. Remember, you don't "get" cold from the wind, you just lose heat.

Radiation

Even with no fan, you feel the heat from the wood stove as you bring your hand close to it. Invisible electromagnetic waves (called infrared light) and visible light bring energy from the hot stove to your hand. This is called radiation.

Radiation is the transfer of energy in the form of electromagnetic waves. Visible light and infrared light are both forms of radiation that transfer heat. Radiation is the reason a car heats up on a sunny day – the energy from the sun is transferred to the car.

Molecules can also transform heat into electromagnetic waves, so that heat is transferred not by molecules but by the waves themselves. A familiar example is the microwave oven, which sends microwave radiation into the food, energizing the molecules in the food without those molecules ever making contact with other, hotter molecules. Radiation takes place when the source of heat is some form of electromagnetic wave, such as a microwave or sunlight.

Keeping Warm

So how can you keep warm in an Arctic winter? People are sources of heat – the food we eat helps to fuel our body's furnace. (People in cold climates eat about twice as many calories as those in warmer climates.) We feel cold when we lose more heat energy than our bodies can produce. To stay warm, we must reduce the flow of heat away from our body. Blankets, coats, and houses are ways that we reduce heat transfer (from conduction, convection, and radiation) from us to the outdoors.

Igloos are also used to provide shelter and warmth for travelers and hunters. But how can an igloo keep you warm when it is made of snow and ice? Snow and ice are actually good insulators. The igloo blocks the wind and, more important, keeps your body heat inside the structure's air space. The snow on the inside of the igloo typically melts and refreezes, making a protective layer.