

Conduction

- Process where heat is _____ through a _____ without any _____ of the material
- The objects are in _____ with each other
- Often happens when energetic _____ molecules bump into less energetic _____ molecules
- When this happens energy is _____

Thermal conductors

- Materials that _____ heat well
- _____

Thermal insulators

- Materials that conduct heat _____
- _____, _____, _____

Conduction of Heat through a Bar

$$\frac{Q}{t} = \frac{kA(T_2 - T_1)}{d}$$

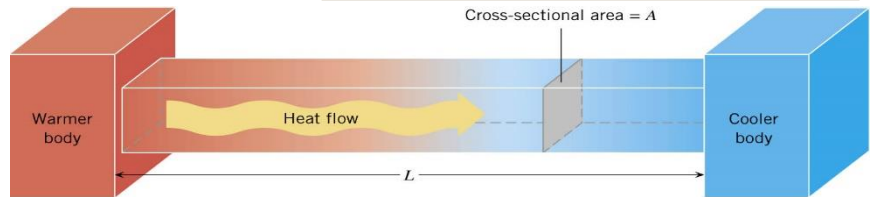
- k = thermal conductivity (Table 14.3), A = cross-sectional area, $T_2 - T_1$ = difference in temperature between ends, t = time of heat transfer, d = length of bar

Table 14.3 Thermal Conductivities of Common Substances^[7]

Substance	Thermal conductivity k (J/s·m·°C)
Silver	420
Copper	390
Gold	318
Aluminum	220
Steel iron	80
Steel (stainless)	14
Ice	2.2
Glass (average)	0.84
Concrete brick	0.84
Water	0.6
Fatty tissue (without blood)	0.2
Asbestos	0.16
Plasterboard	0.16
Wood	0.08–0.16
Snow (dry)	0.10
Cork	0.042
Glass wool	0.042
Wool	0.04
Down feathers	0.025
Air	0.023
Styrofoam	0.010

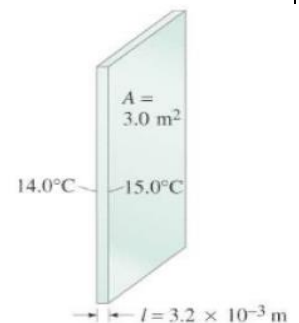
There are two ways to create good insulators

- Small k and big d
- Ratio d/k called _____
 - _____ the R factor, _____ insulator
- Other insulators like _____ and _____ work by _____ air in small spaces where convection currents cannot arise



How much heat is transferred through the Styrofoam insulation the walls of a refrigerator in an hour? The total area of the walls are about 4 m² and the Styrofoam is 30mm thick. The temperature inside is 5°C and the room is 25°C.

A major source of heat loss from a house is through the windows. Calculate the rate of heat flow through a glass window 2.0 m × 1.5 m in area and 3.2 mm thick, if the temperatures at the inner and outer surfaces are 15.0°C and 14.0°C, respectively.



Homework

1. What are the main methods of heat transfer from the hot core of Earth to its surface? From Earth's surface to outer space?
2. Grandma says that it is quicker to bake a potato if you put a nail into it. In fact, she is right. Justify her baking technique in terms of one of the three processes of heat transfer.
3. Concrete walls often contain steel reinforcement bars. Does the steel enhance or degrade the insulating value of the concrete? Explain.
4. (a) Calculate the rate of heat conduction through house walls that are 13.0 cm thick and that have an average thermal conductivity twice that of glass wool. Assume there are no windows or doors. The surface area of the walls is 120 m² and their inside surface is at 18.0°C, while their outside surface is at 5.00°C. (b) How many 1-kW room heaters would be needed to balance the heat transfer due to conduction? (OpenStax 14.30) **1.01 × 10³ W, 1**
5. The rate of heat conduction out of a window on a winter day is rapid enough to chill the air next to it. To see just how rapidly the windows transfer heat by conduction, calculate the rate of conduction in watts through a 3.00-m² window that is 0.635 cm thick (1/4 in) if the temperatures of the inner and outer surfaces are 5.00°C and -10.0°C, respectively. This rapid rate will not be maintained—the inner surface will cool, and even result in frost formation. (OpenStax 14.31) **6.0 × 10³ W**
6. Calculate the rate of heat conduction out of the human body, assuming that the core internal temperature is 37.0°C, the skin temperature is 34.0°C, the thickness of the tissues between averages 1.00 cm, and the surface area is 1.40 m². (OpenStax 14.32) **84.0 W**
7. Suppose you stand with one foot on ceramic flooring and one foot on a wool carpet, making contact over an area of 80.0 cm² with each foot. Both the ceramic and the carpet are 2.00 cm thick and are 10.0°C on their bottom sides. At what rate must heat transfer occur from each foot to keep the top of the ceramic and carpet at 33.0°C? (OpenStax 14.33) **0.368 W, 7.73 W**
8. (a) What is the rate of heat conduction through the 3.00-cm-thick fur of a large animal having a 1.40-m² surface area? Assume that the animal's skin temperature is 32.0°C, that the air temperature is -5.00°C, and that fur has the same thermal conductivity as air. (b) What food intake will the animal need in one day to replace this heat transfer? (OpenStax 14.36) **39.7 W, 820 kcal**
9. A walrus transfers energy by conduction through its blubber at the rate of 150 W when immersed in -1.00°C water. The walrus's internal core temperature is 37.0°C, and it has a surface area of 2.00 m². What is the average thickness of its blubber, which has the conductivity of fatty tissues without blood? (OpenStax 14.37) **10.1 cm**
10. A person's body is covered with 1.6 m² of wool clothing. The thickness of the wool is 2.0 × 10⁻³ m. The temperature at the outside surface of the wool is 11 °C, and the skin temperature is 36 °C. How much heat per second does the person lose due to conduction? (Cutnell 13.1) **800 J/s**
11. In an electrically heated home, the temperature of the ground in contact with a concrete basement wall is 12.8 °C. The temperature at the inside surface of the wall is 20.0°C. The wall is 0.10 m thick and has an area of 9.0 m². Assume that one kilowatt · hour of electrical energy costs \$0.10. How many hours are required for one dollar's worth of energy to be conducted through the wall? (Cutnell 13.3) **18 h**