Lecture 2.4
Heat Transfer

As we said during the previous lecture there are three possible heat transfer mechanisms: conduction, convection and radiation. We have already discussed the first, conduction mechanism. Now let us address the other two.

Convection

If you consider a flame of the candle or the burning match, there you have an example of the thermal energy being transferred upward by convection. This effect occurs because the layer of air or any other fluid in contact with a hot object will perform thermal expansion. As a result, it becomes less dense and experiences the buoyant force from the other cooler and denser layers of fluid, so the less dense layer moves up. At the same time, the cooler layers are moving down and the process continues until the entire fluid is heated.

Radiation

The last way to transfer heat is by means of electromagnetic waves emitted by a heated object. For instance, visible light is one of the examples for such electromagnetic wave. No medium is required for electromagnetic wave to travel. So, the energy of the Sun can heat objects on the Earth's surface without any medium existing between the Sun and the Earth. The rate at which such object emits this radiation depends on the object's surface area $A$ and its temperature $T$

$$P_{\text{rad}} = \sigma \varepsilon T^4,$$  \hspace{1cm} (2.4.1)

where $\sigma = 5.6703 \times 10^{-8} \text{W/m}^2 \text{K}^4$ is the Stefan-Boltzmann constant. The $\varepsilon$-symbol represents emissivity of the object and could take values in the interval between 0 and 1 depending on properties of the surface. The case of $\varepsilon = 1$ refers to the perfect blackbody radiator.

At the same time as they radiate, all the objects absorb radiation from the environment with temperature $T_{\text{env}}$ at rate

$$P_{\text{abs}} = \sigma \varepsilon T_{\text{env}}^4.$$  \hspace{1cm} (2.4.2)

The net radiation rate for the object is the difference between the two rates from equations 2.4.1 and 2.4.2.