Lecture 5

5.1 Heat loss of a person by radiation

A person has an exposed surface of 1.7 m^2, an emissivity of 0.70 and a surface temperature of 32 °C. Determine the rate of heat loss from that person by radiation in a large room whose walls are at a temperature of 27 °C.

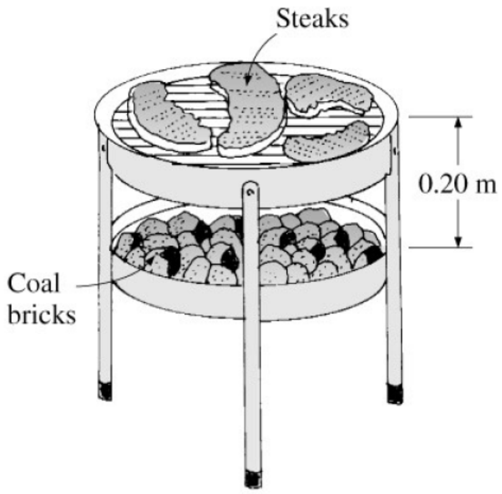
5.2 The BBQ

Consider a circular grill with a diameter of 0.30 m. The bottom of the grill is covered with hot coal bricks at 827 °C, while the mesh on top of the grill is covered with steaks initially at 5 °C. The distance between the coal bricks and the steaks is 0.20 m and the view factor from the coal bricks to the steak is $F_{1\to 2} = 0.28$. Treat both the steaks and the coal bricks as blackbodies.

a) Make a simple diagram of the described situation, with all relevant parameters.

b) Determine the initial rate of radiation heat transfer from the coal bricks to the steaks. Hint: not all the heat radiated by the coal bricks will reach the steaks.

c) Also determine the initial rate of radiation heat transfer to the steaks if the side opening of the grill is covered by aluminium foil, which can be approximated as a re-radiating surface (reflecting all incoming radiation).



5.3 Radiation of heat from a coffee machine

In problem 4.2, the equilibrium temperature of the heater plate surface of a coffee machine has been determined.

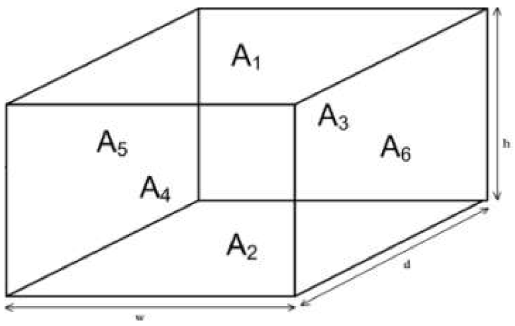
a) Find the emissivity ϵ of the heater plate surface.

b) Find the total thermal resistance between the heater surface and the surroundings as well as the total heat transfer coefficient, including convection and radiation.

5.4 Heating a meal in an oven

The inside of an oven is 0.45 m wide, 0.30 m high and 0.30 m deep. All surfaces can be approximated as blackbodies.

The oven can be seen as a box with 6 faces:



Where:

- $F_{1\to 1} = 0$
- $F_{1\to 2} = 0.26$
- $F_{1\to 3} = F_{1\to 4} = 0.22$
- $F_{1\to 5} = F_{1\to 6} = 0.15$

A meal ($\epsilon = 0.95$, A = 0.085 m^2) is taken out of the oven at a uniform temperature of 180 °C and is immediately wrapped tightly in aluminum foil ($\epsilon = 0.070$, k = 237 W/mK). The ambient temperature of the room is 25 °C. Heat is transferred from the meal to the environment by natural convection and radiation. The convection heat transfer coefficient (directly after taking the meal out of the oven) is determined to be 10 W/m^{2}K^1.

a) Show that it is reasonable to assume that the surface temperature of the meal is the same for the wrapped and unwrapped case by estimating/calculating and comparing the heat resistances involved in this problem. Explain your answer.

b) Determine the total rate of heat loss from the wrapped meal for this situation. What is the percentual reduction with respect to the unwrapped case?

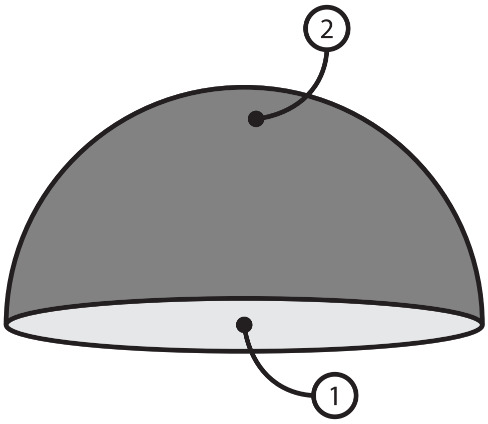
c) At which wavelength the power emitted from the meal by radiation is maximum? What type of radiation is this? Use the chart of the electromagnetic spectrum.

d) Can thermal radiation of the meal be seen by human eyes? Support your answer with a calculation.

5.5 Radiation in a hemispherical furnace - Hand in

A hemispherical furnace is being used, with a black curved dome maintained at a constant uniform temperature of 1000 K. The grey base is also kept at a constant uniform temperature of 400 K, and it has an emissivity of 0.7. The dome's diameter is 5 meters. All surfaces are opaque and diffuse and convection is negligible.

The oven can be seen as a hemisphere with 2 faces, the dome (=2) and the base (=1).



Where

- $F_{1\to1} = 0$
- $F_{1\to2} = 1$
- $F_{2\to1} = \frac{1}{2}$
- $F_{2\to2} = \frac{1}{2}$

a) Determine the net rate of radiation heat transfer from the dome to the base surface.

b) At which wavelength the power emitted from the dome by radiation is maximum? W