SUMMARY

The convection of heat occurs when the particles of one material move relatively to each other, in fluids, liquids or gaseous.
Convective motions are mainly due to the following phenomenon: a fluid, if its temperature increases, tends to expand, decreasing its density; while if it cools, its density grows and the liquid contracts. The hydrostatic balance is therefore lacking and the force of gravity causes denser portions of liquid to move downwards, and warmer portions are pushed upwards. This is the natural convection.
In the case of forced convection, the fluid currents are artificially caused and to carry out the transport of heat it is necessary to do external work to keep the currents in the fluid.

Convection heat depends on: DeltaTemperature, the speed of the fluid and the kind of the fluid.
As it happens in the conduction phenomenon, also the convection resistances have an analogy with the electric resistances.

$Q^{dot} = (T_{\infty 1} - T_{\infty 2}) / R_{tot}$ [W]

where Q^{dot} is the heat transfer
$T_{\infty 1}$ is the homogeneus temperature of the room
$T_{\infty 2}$ is the (lowest) temperature outside

and $R_{tot} = R_{conv1} + R_{wall} + R_{conv2} = (1 / h_1 A) + (L / kA) + (1 / h_2 A)$ [°C/W]

Why increasing the thickness of a single pane glass does not increase the total resistance?

The resistance of the glass is too low to be able to change the total thermal resistance, even increasing its thickness. Instead of increasing this one, it’s more efficient to increase the air between the two panes of glass, with a value that goes from 6mm to 13mm.

Mistakes in class

In the first question I have approximated the result too much, from 1,116 to 1. This changed the result of my Q^{dot} from 266 W to 300 W.

But the main error I have done is the answer of the third question: I said that the factor that increments more the Q^{dot} is the total resistance because it’s inversely proportioned to Q.

EXERCISE

Double pane window 0,8m high and 1,5m wide.
Glass: 6mm thick (k=0,78 W/m°C)
Air space: 13mm (k=0,026 W/m°C)
h_1= 10 W/m^2 °C
h_2= 40 W/m^2 °C
$T_{\infty 1}$ = 20°C
$T_{\infty 2}$ = -10°C
Determine the steady rate of heat transfer through the window and the temperature of its inner surface.

A_{glass}=0,8 x 1,5 = 1,2m^2

$R_{total} = R_{conv1} + 2(R_{glass}) + R_{air} + R_{conv2}$

$R_{conv1} = (1 / h_1A)$ = 1 / 12 °C/W = 0,0833 °C/W
$R_{glass} = L_{glass} / k_{glass}A$ = 0,006 / 0,78 x 1,2 °C/W = 0,0064 °C/W
$R_{air} = L_{air} / k_{air}A$ = 0,013 / 0,026 x 1,2 °C/W = 0,4166 °C/W
$R_{conv2} = (1 / h_2A)$ = 1 / 48 °C/W = 0,0208 °C/W

R_{total} = 0,5335 °C/W

$Q^{dot} = (T_{\infty 1} – T_{\infty 2}) / R_{tot}$ = 30 / 0,5335 = 56,2324 W

$T_1 = T_{\infty 1} - Q^{dot} \times R_{conv1}$ = 20 – 56,2324 x 0,0833 °C = 15,3159 °C

13 mm is the optimal range because it is the higher thinckness we can use before having convection between the two panes of glass.