Question 1

1.1 The Convective Heat Transfer

Convective Heat Transfer is heat transferred between a surface (Solids) and liquids with different temperatures.

There are 2 types of Convection:

- Forced Convection : A Fan & Winds
- Natural Convection: Cold & Hot Air Movement

The process of convection is observed with the heat transfer from a wall section and how the it allows the temperature transfer from the outside in. The Air (outside) is getting warm due to its proximity to the wall so it goes up and the cold air goes down. The Air (inside) hot air is going up and cold air goes down.

The rate of convective Heat Transfer depends on Certain Parameters:

- Temperature
- Wind Speed (in case of forced Convection), velocity of liquid or gas.
- Area
- The Material.

We can calculate the Convective Heat Transfer with Newton's Law of Cooling where:

$\dot{Q} = hA_s(T_S - T_\infty)$, where T_∞ is the temperature of the air where is not affected by the temperature of wall, where it becomes a homogenous temperature. And T_s is the temperature of the surface (in this case, the wall)

Forced convection will have a higher h than natural convection. The higher the H the lower the R.

When calculating the $\dot{Q}$, you always assume that it is always in a steady condition and you consider highest wind speed as a worst case scenario so that you know the heat transfer in the worst condition.

1.2 Glass Thickness and its impact on Resistance:

Glass thickness does not impact the heat transfer because it's resistance is almost 10 times less than the convection resistance. No matter how much we increase the thickness, it will never be enough to impact or increase the total resistance. Which is why we add air gaps, to assist and increase the total resistance.

Question 2

The mistake I did was in the double pane window, I did not double the glass in the equation

$$R_{Total} = R_{cov1} + R_{cov2} + 2\,R_{Glass} + R_{AirGap}$$

I used glass as one layer and therefore I got the R_{Total} wrong.

Question 3

Consider a 0.8-m-high and 1.5-m-wide double-pane window consisting of two 6-mm-thick layers of glass (k=0.78 W/m.°C) separated by a 13-mm-wide stagnant air space (k=0.026 W/m.°C).

Determine the steady rate of heat transfer through this double pane window and the temperature of its inner surface.

Take the convection heat transfer coefficients on the inner and outer surfaces of the window to be h1=10 W/m2 · °C and h2=40 W/m2 · °C, which includes the effects of radiation.

Solution:

$$\dot{Q} = \frac{T_{\infty 1} - T_{\infty 2}}{R_{Total}}$$

$$R_{Total} = R_{cov1} + R_{cov2} + 2\ R_{Glass} + R_{AirGap}$$

$$K_{Glass} = 0.78\ W/m\ ℃$$

$$K_{AirGap} = 0.0026\ W/m\ ℃$$

3.1 Steady rate of heat transfer

Area = 0.8 m x 1.5m = 1.2 m2

H1 = 10 W/m2 H2 = 40 W/m2

$R_{cov1} = 0.08333$
$R_{cov2} = 0.020833$

$2\ R_{Glass} = 2\ (\ 0.000641)$

$R_{AirGap} = 0.41667$

$\boldsymbol{R_{Total} = 0.52725\ ℃/W}$

$\dot{Q} = \frac{T_{\infty 1} - T_{\infty 2}}{R_{Total}}$
$\boldsymbol{\dot{Q} = \frac{20-(-10)}{0.52725} = 56.89933\ W}$

3.2 Temperature of its inner surface:

$T_1 = T_{\infty 1} - (\dot{Q} * 1/h_1 A)$

$$\boldsymbol{T_1 = 20 - (56.89933 * 0.08333) = 15.2586}\ ℃$$

3.3 Results Conclusion:

The glass resistance is very low, it does not have an effect on heat transfer. The only parameter with a considerable impact on heat resistance is the AirGap resistance.

3.4 Optimal range for the air-gap's distance

We have an optimal air gap distance so that it will have a significant impact on heat transfer, if the thickness goes beyond the range, it will no longer have an impact and will increase the heat transfer process rather than resisting it.