Assignment 2

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Questions:

1. Write a summary about the convective heat transfer and explain why increasing the thickness of a single pane glass does not increase the total resistance.
2. Write an explanation about what mistakes you made in the class that resulted in wrong answers.
3. Solve the same problem as that of double pane window with the air-gap thickness of 13 mm and glass thickness of 6 mm, comment on your results and explain why we have an optimal range for the air-gap's distance?

Question 1:

→ Convection describes heat transfer between a surface and a liquid or gas in motion.

such as air or water when the heated fluid is caused to move away from the source of heat, carrying energy with it.

Convection happens when there is a difference in temperature between two parts of a liquid or gas. The contact with the heat source warms up the solid, forcing them to expand and displace more air, which gets heated in turn. This is what is known as convection current.

After expanding, the hot air becomes less dense, and rises; and the cooler part sinks.
As the fluid or gas travels faster, the convective heat transfer increases.

There are two types of convection: natural convection and forced convection.

In natural convection, fluid motion results from the hot atoms in the fluid, where the hot atoms move upwards toward the cooler atoms in the air; the fluid moves under the influence of gravity. In forced convection, the fluid is forced to travel over the surface by another external source.

→ Increasing the thickness of a single pane glass does not increase the total resistance because the thermal resistance of the glass itself is already minor in parallel to the convection between air and glass. So increasing the thickness of the glass does not have a substantial effect on the total thermal resistance.

Question 2:

Forgot to convert from mm to m

Question 3

→ Area of the surface:

$A_{glass} = 0.8*1.5 = 1.2m^2$

→ Thermal resistance of the material (glass 6mm thick):

$R_{glass} = \frac{L_{glass}}{K*A} = \frac{0.006}{0.78*1.2} = 0.0064$ ˚C/W

Both layers of glass are of the same thickness so $R_{glass1} = R_{glass2} = 0.0064$ ˚C/W

→ Thermal resistance of convection between inner surface and air:

$R_{conv1} = \frac{1}{h1*A} = \frac{1}{10*1.2} = 0.0833$ ˚C/W

→ Thermal resistance of the convection between outer surface and air:

$R_{conv2} = \frac{1}{h2*A} = \frac{1}{40*1.2} = 0.0208$ ˚C/W

→ Thermal resistance of air space (13mm wide):

$R_{air} = \frac{L_{air}}{K_{air}*A} = \frac{0.013}{0.026*1.2} = 0.4167$ ˚C/W

→ Total thermal resistance of the window:

$R_{total} = R_{conv1} + R_{glass1} + R_{air} + R_{glass2} + R_{conv2}$

$R_{total} = 0.0833 + 0.0064 + 0.4167 + 0.0064 + 0.0208$

$R_{total} = 0.5333$ ˚C/W

→ Steady rate of heat transfer through the double layer window:

$Q = \frac{\Delta T}{R_{total}} = \frac{T\infty 1 - T\infty 2}{R_{conv1}} = \frac{20-(-10)}{0.5333} = 56.2535W$

$Q = \frac{T\infty 1 - T1}{R_{conv1}}$

$T_1 = T_{\infty 1} - Q*R_{conv1} = 20 - 56.2535*0.0833 = 15.3$ ˚C/W

→ So the temperature of the inner surface of the window is 15.3 ˚C/W