Guidelines for this week's submission:

1. **Write a summary (in your own words!!) about the convective heat transfer (half a page) and explain why increasing the thickness of a single pane glass does not increase the total resistance**

   Convective heat transfer, also known as heat convection, is one of the three ways of heat transfer. It happens between two moving fluids (liquid and gas, liquid and liquid, gas and gas, etc.), or a solid and a moving fluid (e.g., gas and solid). For example, heat transfer between a solid wall and air (interior or exterior) is convection.
   There are two types of convection - natural convection & forced convection. Natural convection occurs due to difference in density caused by temperature variation in fluids. Forced convection occurs due to the presence of an external force, such as wind.

   The rate of convective heat transfer depends on: Temperature difference, Velocity of fluid, Nature of fluid

   According to Newton's law of cooling, the rate of convective heat transfer $(\dot{Q_{conv}})$:

$$\dot{Q_{conv}} = \mathrm{h}A_s(T_s - T_\infty), \ \ where\ 'h'\ is\ a\ coefficient\ related\ to\ the\ velocity\ of\ the\ fluid$$

$$\dot{Q_{conv}} = \frac{(T_s - T_\infty)}{R_{conv}} \quad \Rightarrow \quad R_{conv}$$

$$= \frac{1}{\mathrm{h}A_s} \ , \ \ where\ R_{conv}\ is\ the\ thermal\ resistace\ of\ the\ surface\ to\ heat\ convection$$

Increasing the thickness of a single pane glass does not increase the thermal resistance. This is because, heat transfer through the glass pane occurs through conduction. The conductive resistance of the single pane glass is calculated as: $\mathrm{R_{cond}} = \frac{\mathrm{L}}{kA}$

The thermal resistance of glass is a quite small value compared to the thermal resistance of convection between glass and air. Increasing the thickness of a single glass can increase the thermal resistance of the glass, but it does not significantly increase the total thermal resistance.

2. Write an explanation about what mistakes you made in the class that resulted in wrong answers !!

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3. **Solve the same probelm as that of double pane window with with the air-gap thickness of 13 mm and glass thickness of 6 mm, commment on your results and explain why we have an optimal range for the air-gap's distance !**

$$A = 0.8 \times 1.5 = 1.2\ m^2$$
$$k_{glass} = 0.78\ W/m°C$$
$$k_{air} = \ 0.026 \frac{W}{m} °C$$
$$L_{glass} = 6\ mm$$
$$L_{air} = 13\ mm$$

$$h_1 = \ 10 W/m°C$$
$$h_2 = \ 40 W/m°C$$

$$R_{total=}\ R_{1conv} + (R_{glass} \times 2) + R_{air} + R_{2conv}$$
$$= \frac{1}{h_1 A} + \left(\frac{L_{glass}}{k_{glass} A} \times 2\right) + \left(\frac{L_{air}}{k_{air} A}\right) + \ \frac{1}{h_2 A}$$
$$= \frac{1}{12} + \frac{0.012}{0.936} + \frac{0.013}{0.0312} + \frac{1}{48}$$
$$= 0.08333 + 0.01282 + 0.41666 + 0.02083$$
$$\Rightarrow R_{total=}\ = 0.53364\ ° \frac{C}{W}$$

$$\dot{Q_{conv}} = \frac{(T_{\infty 1} - T_{\infty 2})}{R_{total}} = 20\ - \frac{(-10)}{0.53364} = 56.3\ W$$

The results show that the air gap provides additional resistance to heat transfer due to poor thermal conductivity of air. Thus, the rate of heat transfer is further reduced. The air gap thickness has an optimal range within which the thermal heat transfer through the double pane glass can be reduced. This is because the air gap provides high conductive resistance to heat. However, when this gap increases in width beyond the threshold, the effect of conductive heat transfer reduces and convection begins to take place within the air gap. Therefore, the resistance to heat transfer decreases.