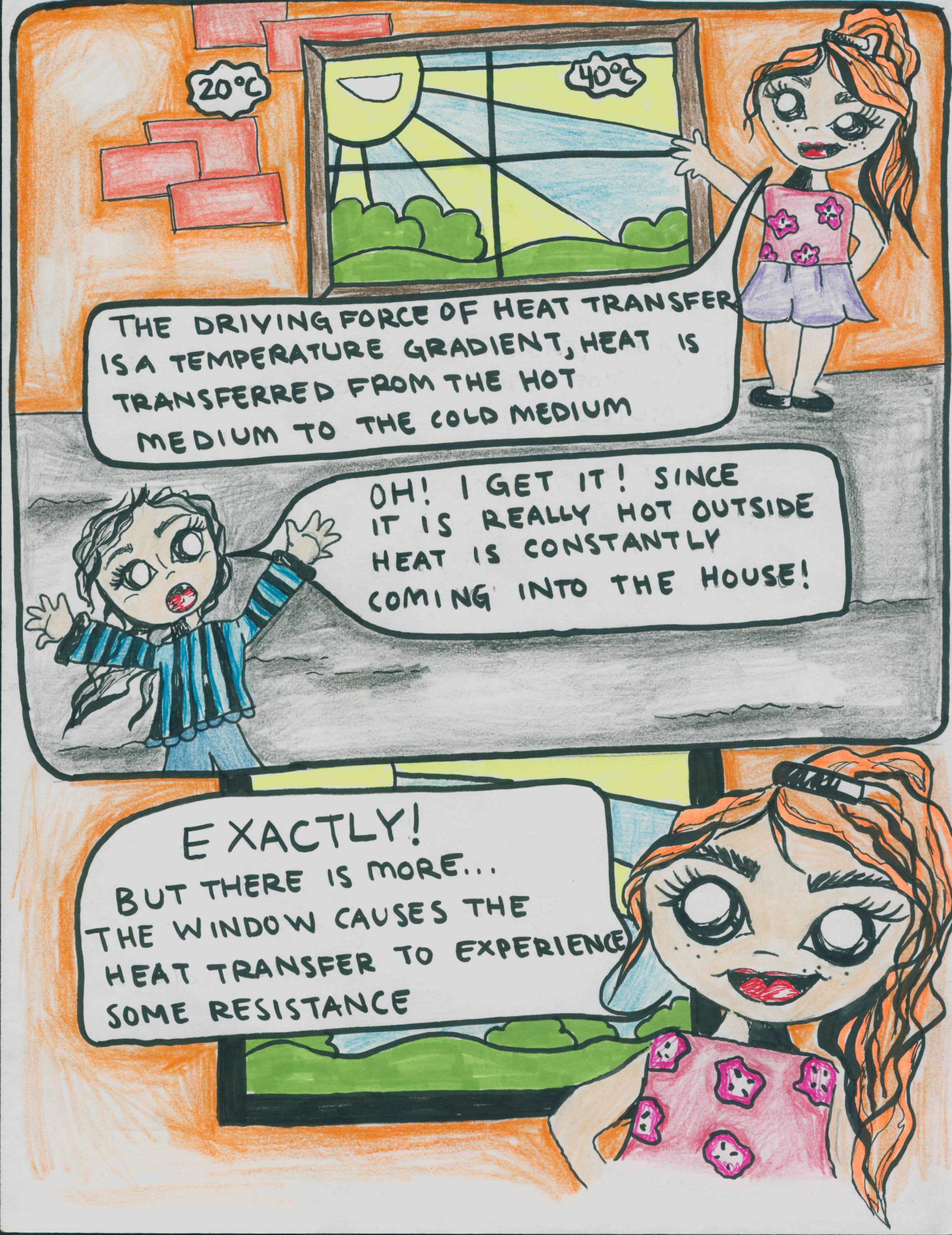
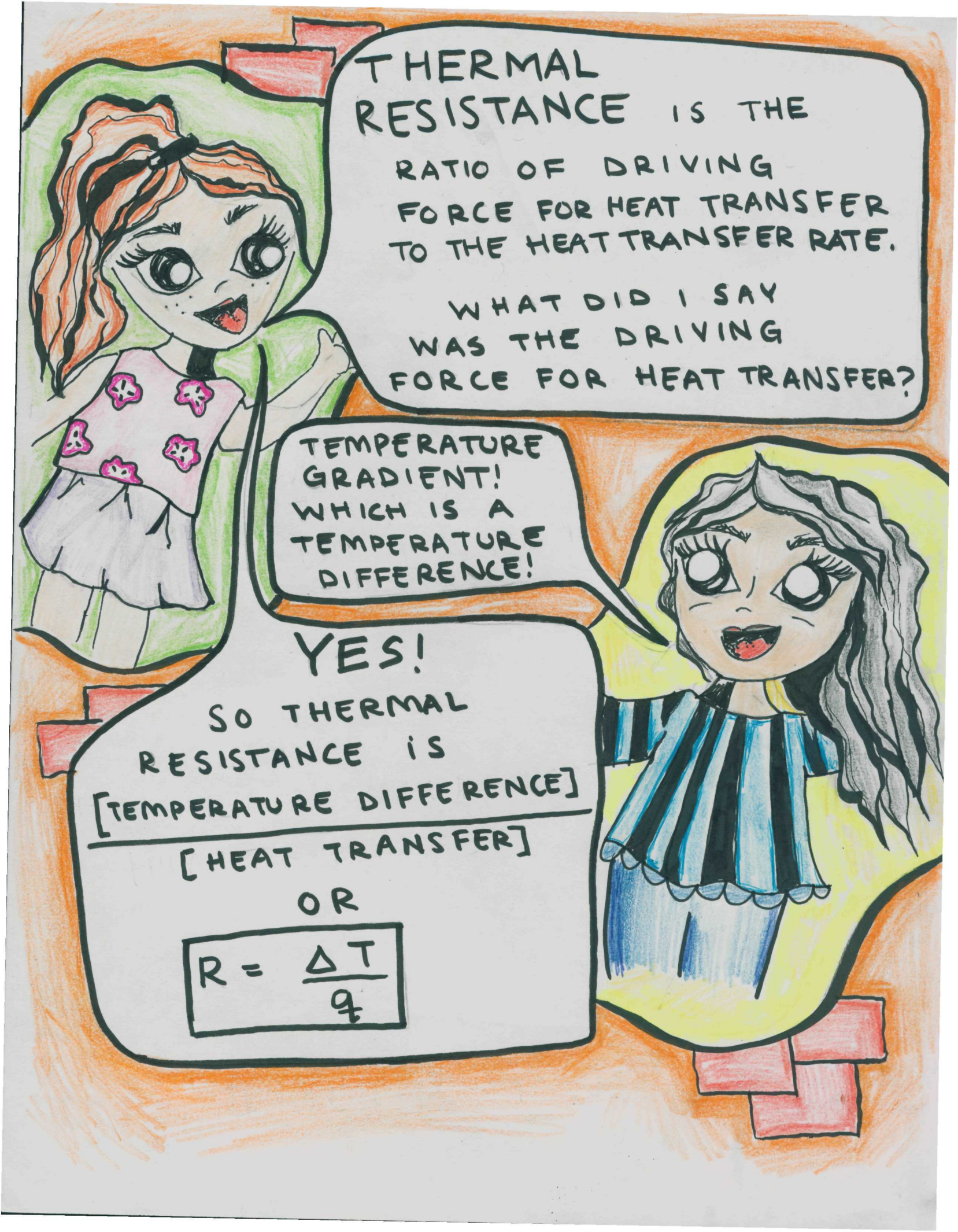
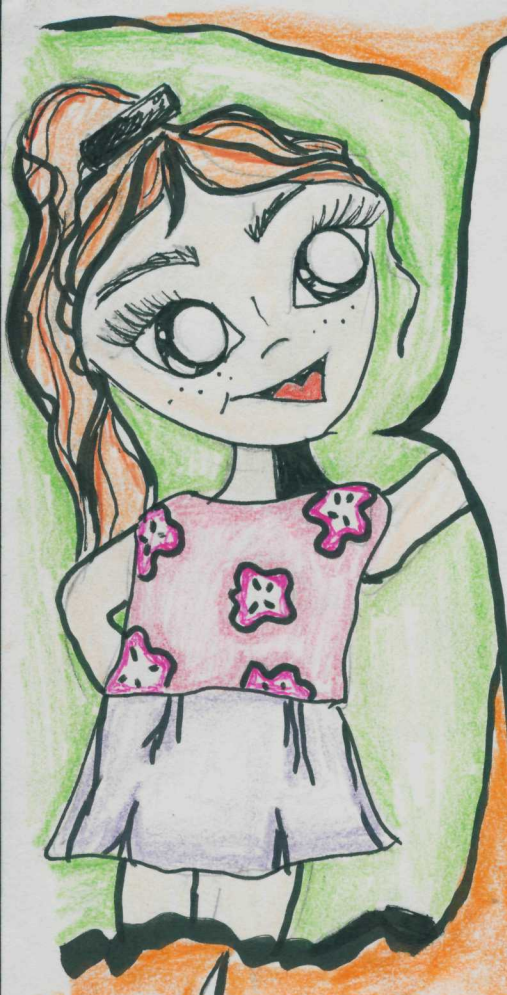
THERMAL RESISTANCE

by: Sophia Little


20°C
40°C
THE DRIVING FORCE OF HEAT TRANSFER IS A TEMPERATURE GRADIENT, HEAT IS TRANSFERRED FROM THE HOT MEDIUM TO THE COLD MEDIUM
OH! I GET IT! SINCE IT IS REALLY HOT OUTSIDE HEAT IS CONSTANTLY COMING INTO THE HOUSE!
EXACTLY!
BUT THERE IS MORE... THE WINDOW CAUSES THE HEAT TRANSFER TO EXPERIENCE SOME RESISTANCE


THERMAL RESISTANCE IS THE RATIO OF DRIVING FORCE FOR HEAT TRANSFER TO THE HEAT TRANSFER RATE.
WHAT DID I SAY WAS THE DRIVING FORCE FOR HEAT TRANSFER?
TEMPERATURE GRADIENT! WHICH IS A TEMPERATURE DIFFERENCE!
YES!
SO THERMAL RESISTANCE IS
[TEMPERATURE DIFFERENCE] / [HEAT TRANSFER]
OR
$R = \frac{\Delta T}{q}$


SO, WHY DO YOU THINK A DOUBLE PANE WINDOW WILL DECREASE THE ENERGY BILL?
WILL IT INCREASE THE RESISTANCE AND DECREASE THE AMOUNT OF HEAT TRANSFERRED INTO THE HOUSE, HELPING US CONSERVE ENERGY?!?
YES! BUT TO UNDERSTAND WHY, YOU NEED TO UNDERSTAND CONDUCTION & CONVECTION.
TEACH ME!



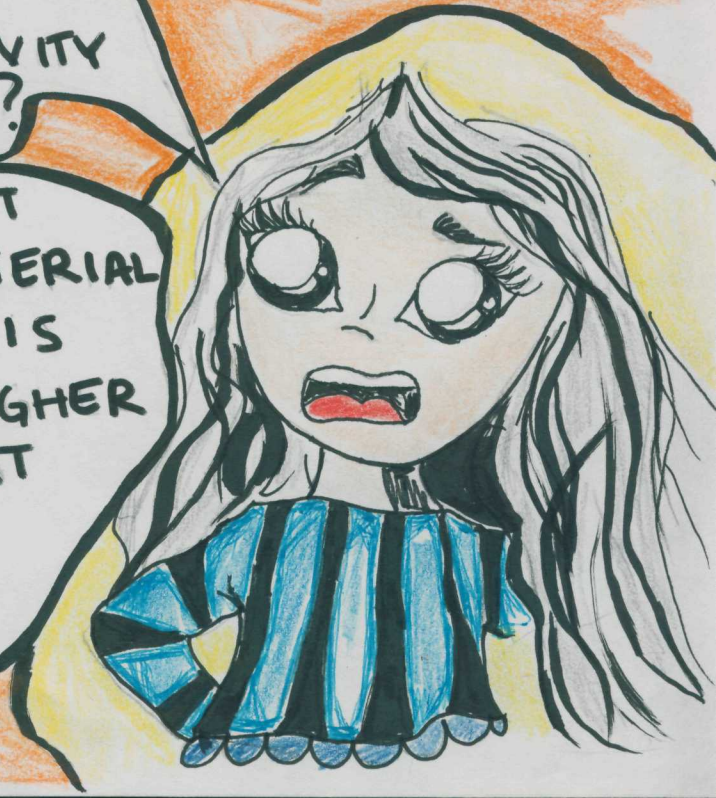
IN THIS CASE CONDUCTION HAPPENS WHEN HEAT IS TRANSMITTED DIRECTLY THROUGH THE GLASS WINDOW.
AND IT IS DESCRIBED BY FOURIER'S LAW:

$$q''_t = -K \frac{dT}{dx}$$

WHERE
- q''_t IS HEAT RATE PER AREA.
- $\frac{dT}{dx}$ IS TEMPERATURE DIFFERENCE WITH RESPECT TO CHANGE IN LENGTH.
- K IS THE THERMAL CONDUCTIVITY CONSTANT.

I GET THAT BUT WHAT IS THE THERMAL CONDUCTIVITY CONSTANT k?

K IS A CONSTANT THAT DEPENDS ON THE MATERIAL THROUGH WHICH HEAT IS TRANSFERRED, THE HIGHER THE K, THE MORE HEAT TRANSFER WILL BE EXPERIENCED.



CONDUCTIVE THERMAL RESISTANCE DEPENDS ON THIS K CONSTANT:

$$R_{t,cond} = \frac{L}{kA}$$

. IT ALSO DEPENDS ON THE LENGTH AND CROSS SECTIONAL AREA THROUGH WHICH HEAT IS TRANSFERRED.

WHAT ABOUT CONVECTION??

CONVECTION IS HEAT TRANSFER THROUGH FLUIDS. IT HAPPENS ON THE INSIDE AND OUTSIDE OF THE WINDOW.

IT IS DESCRIBED BY

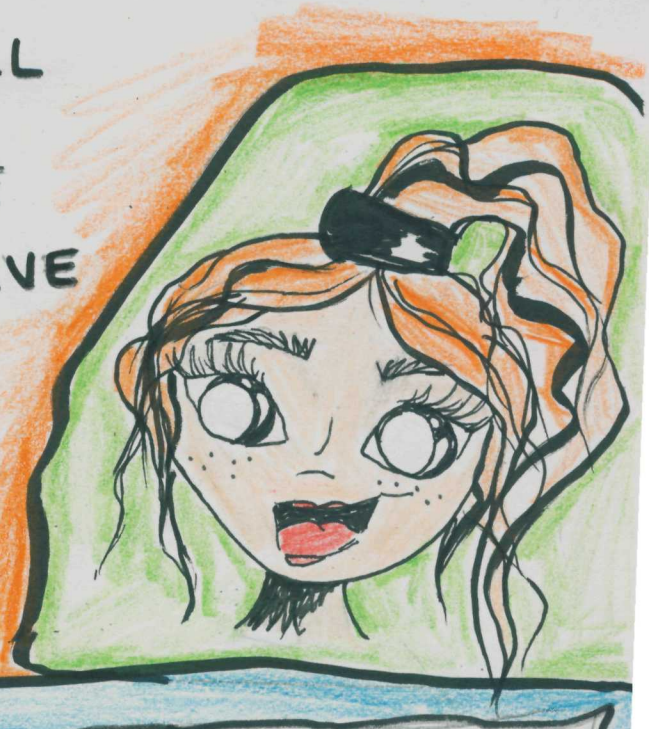
$$q'' = h(T_{outside} - T_{inside})$$

- q'' IS HEAT RATE PER AREA
- $T_{outside}$ and T_{inside} ARE THE TEMPERATURES OF THE OUTSIDE AND INSIDE.
- h is THE CONVECTIVE HEAT TRANSFER COEFFICIENT.

OH, AND h, JUST LIKE k, AFFECTS CONVECTIVE THERMAL RESISTANCE: $R_{t,conv} = \frac{1}{hA}$

IF WE PUT THIS ALL TOGETHER, TOTAL RESISTANCE IS THE SUM OF ALL CONDUCTIVE AND CONVECTIVE RESISTANCES!

LET ME WRITE IT DOWN...



TOTAL RESISTANCE FOR SINGLE PANE WINDOW:

$$R_{total\ (1)} = \frac{1}{h_{in} \cdot A} + \frac{L}{k_{glass} \cdot A} + \frac{1}{h_{out} \cdot A}$$

IN h_{in} | k_{glass}, L GLASS | OUT h_{out}

TOTAL RESISTANCE FOR DOUBLE PANE WINDOW:

$$R_{total\ (2)} = \frac{1}{h_{in} A} + \frac{L_{(1)}}{k_{glass} A} + \frac{L_{(2)}}{k_{air} A} + \frac{L_{(3)}}{k_{glass} A} + \frac{1}{h_{out} \cdot A}$$

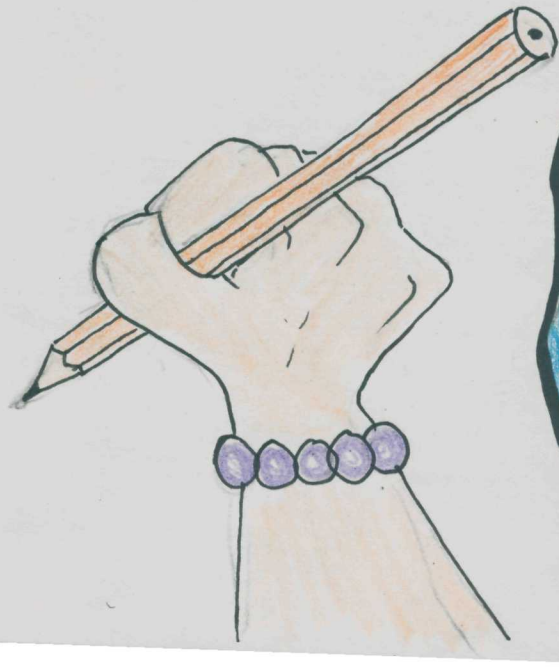
IN h_{in} | k_{glass}, $L_{(1)}$ GLASS | k_{air}, $L_{(2)}$ AIR | k_{glass}, $L_{(3)}$ GLASS | OUT h_{out}

$k_{glass} = 0.04\ W/m \cdot K$

$k_{air} = 0.026\ W/m \cdot K$

THEREFORE,

$$R_{total\ (1)} < R_{total\ (2)}$$




LET ME SEE
OH! THIS MAKES SENSE! IF WE GET DOUBLE PANE WINDOWS OUR ELECTRICITY BILL WILL GO DOWN BECAUSE THE RESISTANCE WILL INCREASE!
LET'S GET DOUBLE PANE WINDOWS! AND THANK YOU FOR TEACHING ME HEAT TRANSFER!
YOU ARE WELCOME!
THE END