

Heat transfer in buildings

Video n°1

# Thermal-electrical analogy

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vidéo réalisée le 08/10/2015



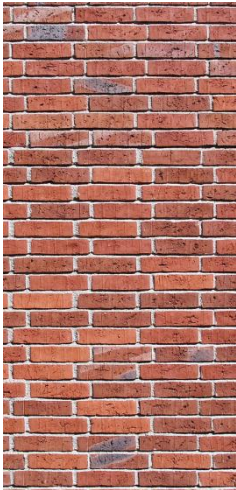


Diagram showing a brick wall with temperature points  $T_1$  (red dot) and  $T_2$  (blue dot) on opposite sides. An arrow indicates heat flux  $\varphi$  through the wall.

$$\varphi = \frac{\lambda}{e} (T_1 - T_2) = \frac{\Delta T}{R} \quad [\text{W/m}^2]$$

Electrical  
analogy




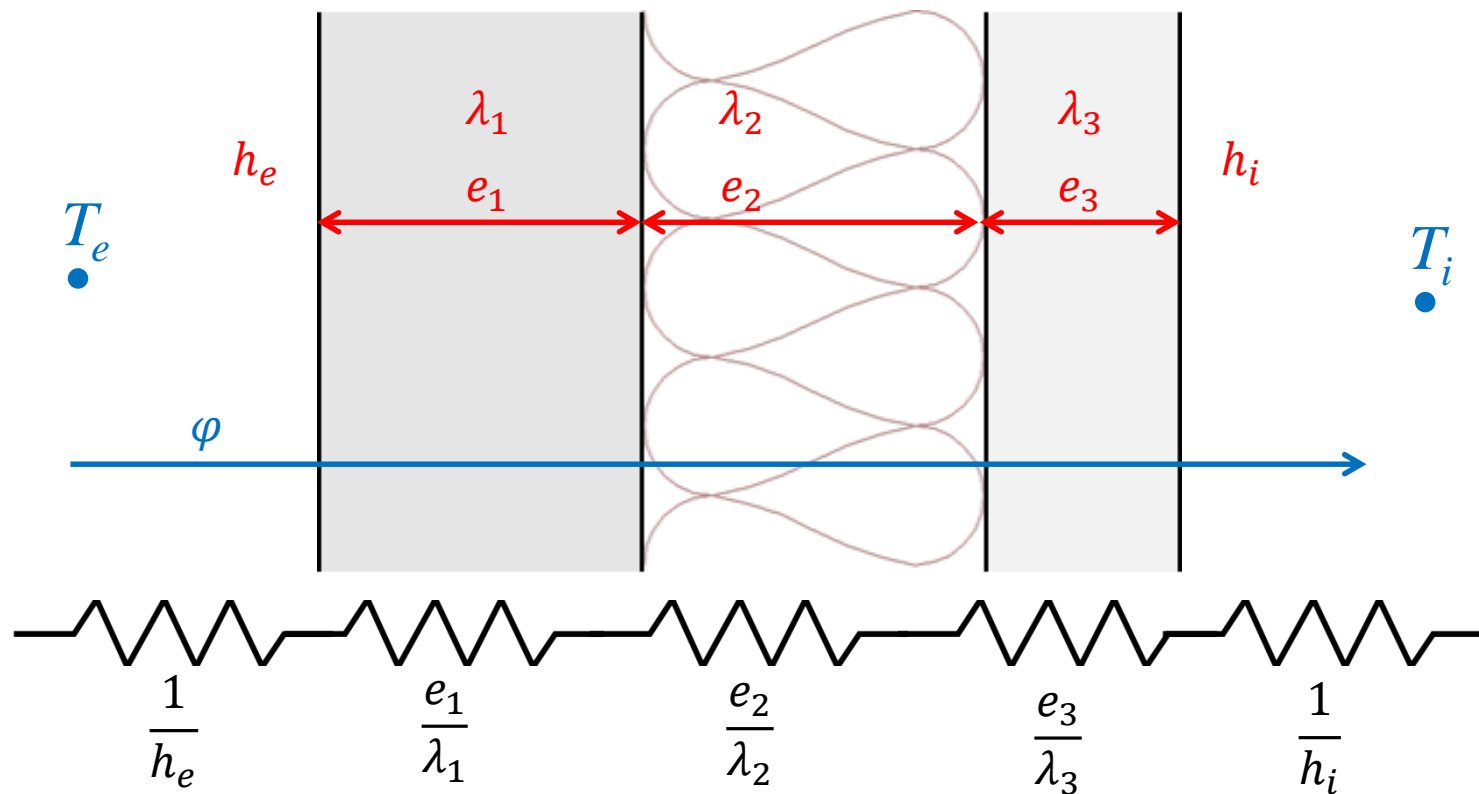
Diagram showing an electrical circuit with a resistor connected between two voltage points  $U_1$  and  $U_2$ . An arrow indicates current  $I$  flowing through the resistor.

$$I = \frac{\Delta U}{R}$$

|                         |                                 |
|-------------------------|---------------------------------|
| Temperature             | = Voltage                       |
| Heat flux               | = Current                       |
| $\Delta T = R \varphi$  |                                 |
| $R = \frac{e}{\lambda}$ | $[\text{m}^2 \cdot \text{K/W}]$ |

or  $\varphi = U \Delta T$  with  $U = \frac{1}{R} \quad [\text{W/m}^2 \cdot \text{K}]$





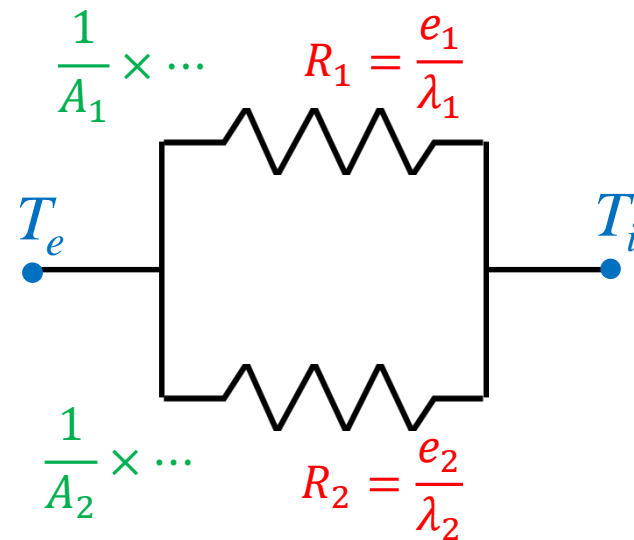
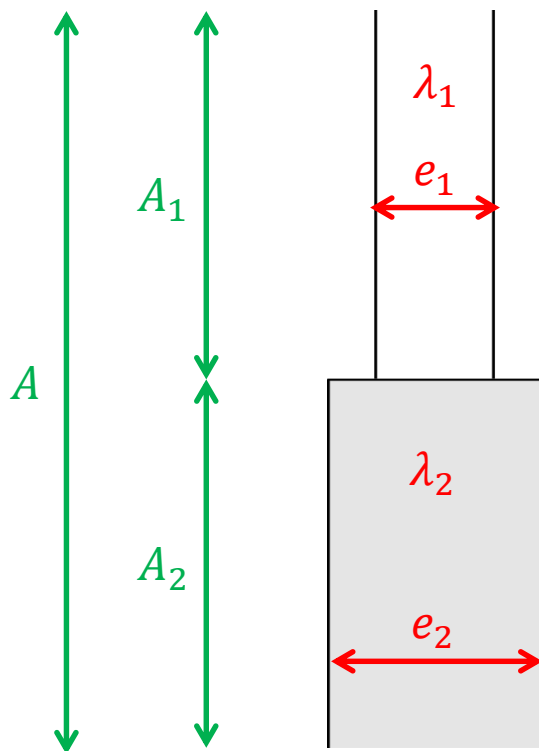
$$\Delta T = R_{total} \times \varphi \quad \text{where} \quad R_{total} = \frac{1}{h_e} + \frac{e_1}{\lambda_1} + \frac{e_2}{\lambda_2} + \frac{e_3}{\lambda_3} + \frac{1}{h_i}$$

$$\varphi = U \Delta T \quad \text{where} \quad U = \frac{1}{R_{total}} = \frac{1}{\frac{1}{h_e} + \frac{e_1}{\lambda_1} + \frac{e_2}{\lambda_2} + \frac{e_3}{\lambda_3} + \frac{1}{h_i}}$$



| Variable  |                      | Dimension           |                                 |
|-----------|----------------------|---------------------|---------------------------------|
| $T$       | Temperature          | K                   |                                 |
| $\lambda$ | Conductivity         | W/m.K               |                                 |
| $h$       | Transfer coefficient | W/m <sup>2</sup> .K |                                 |
| $R$       | Resistance           | m <sup>2</sup> .K/W | adds up in series               |
| $U$       | Transmittance        | W/m <sup>2</sup> .K | does not add up in series       |
| $\varphi$ | Heat flux            | W/m <sup>2</sup>    | flow of energy per unit of area |
| $\phi$    | Total heat flux      | W                   | total flow of energy            |





~~$[W/m^2] + [W/m^2] = [W/m^2]$~~

$[W] + [W] = [W]$

$$\Phi = A \cdot U \cdot (T_e - T_i)$$

$\nwarrow$   $\nearrow$   
 $[W]$        $[m^2]$

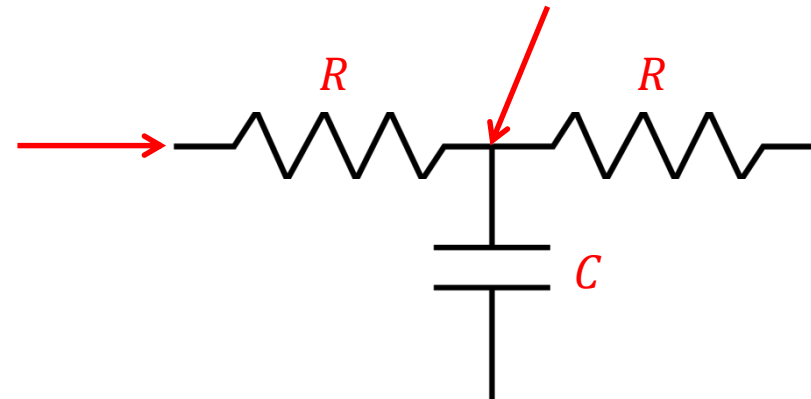
with  $A \cdot U = A_1 U_1 + A_2 U_2$

$$U_1 = \frac{1}{R_1} = \frac{\lambda_1}{e_1}$$

$$U_2 = \frac{1}{R_2} = \frac{\lambda_2}{e_2}$$

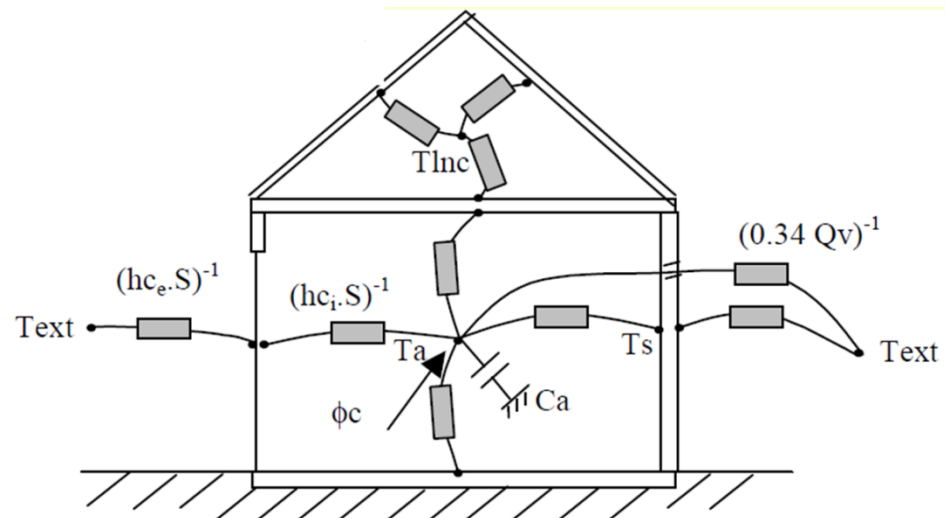


- Transient transfer



- Heat input

- Air transfer, convection, radiation...



## Exercise

