Heat transfer in buildings

Video n°5

Longwave radiation

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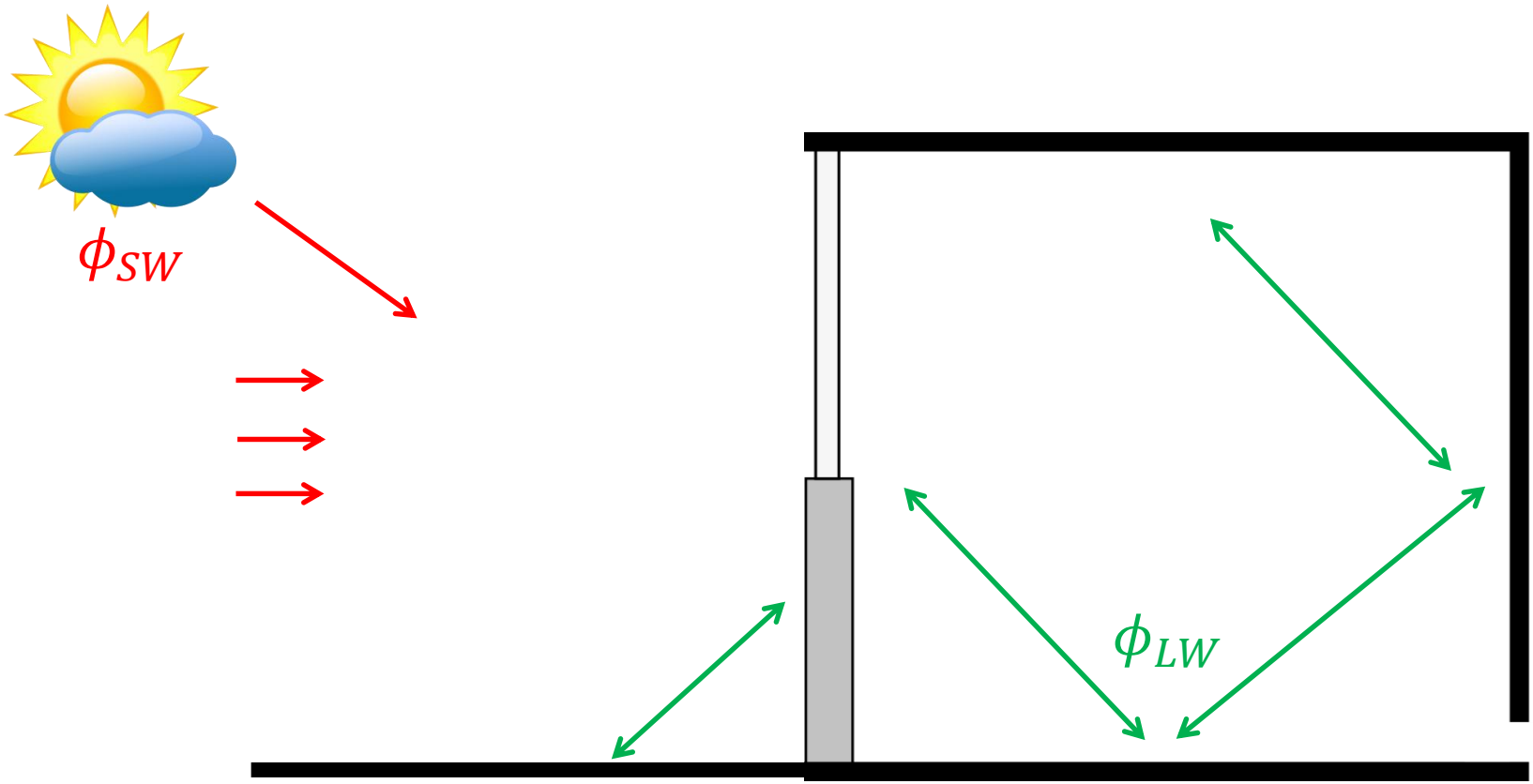
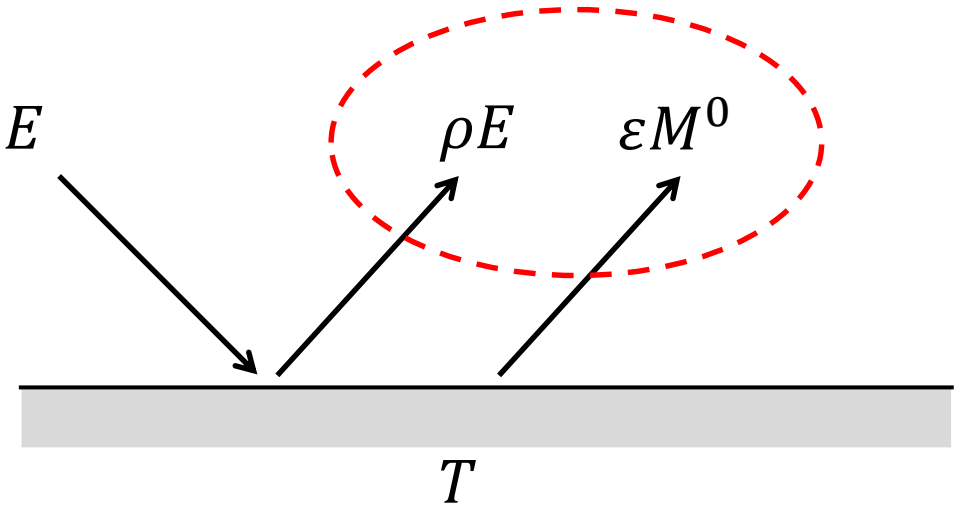
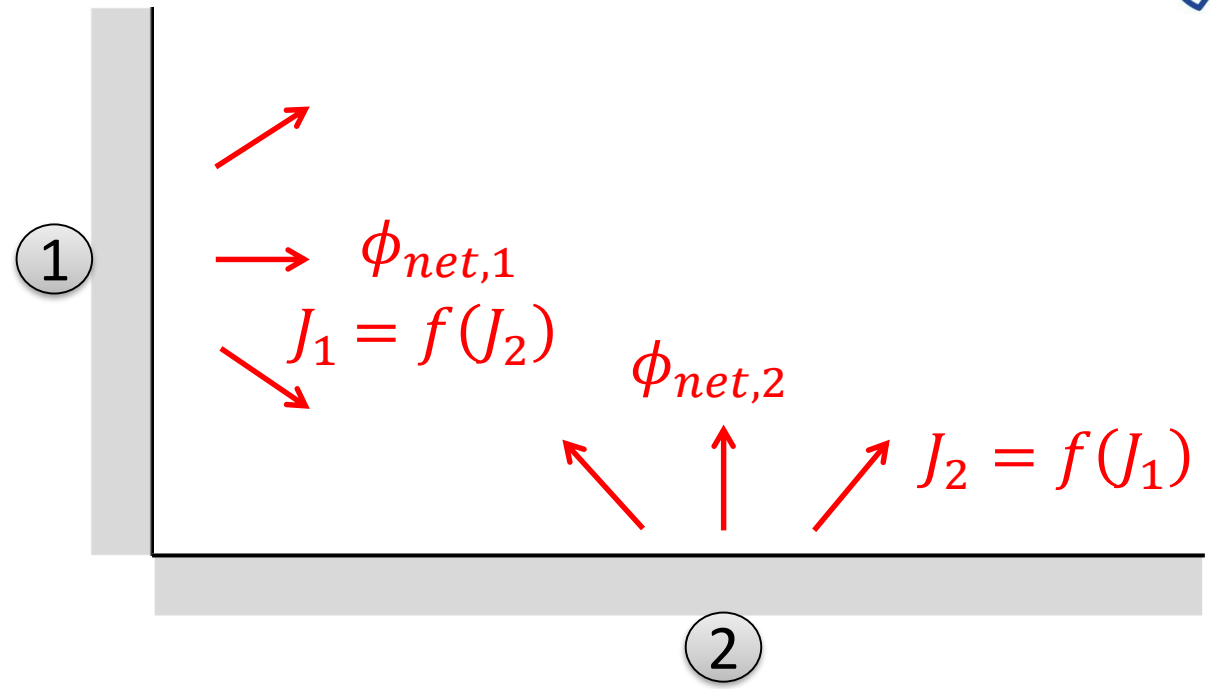

ϕ_{SW}
ϕ_{LW}

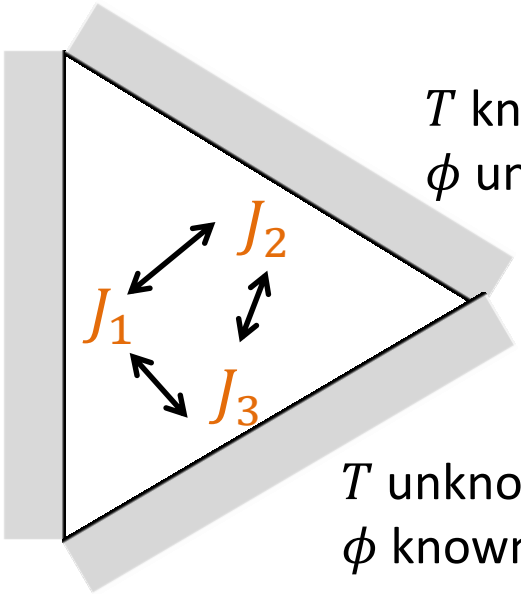
$$J = \varepsilon M^0 + \rho E$$



where $M^0 = \sigma T^4$

E	Incident radiation	[W/m2]
M^0	Black body emission	
J	Radiosity	
ρ	Reflectivity	[-]
ε	Emissivity	





T known
ϕ unknown

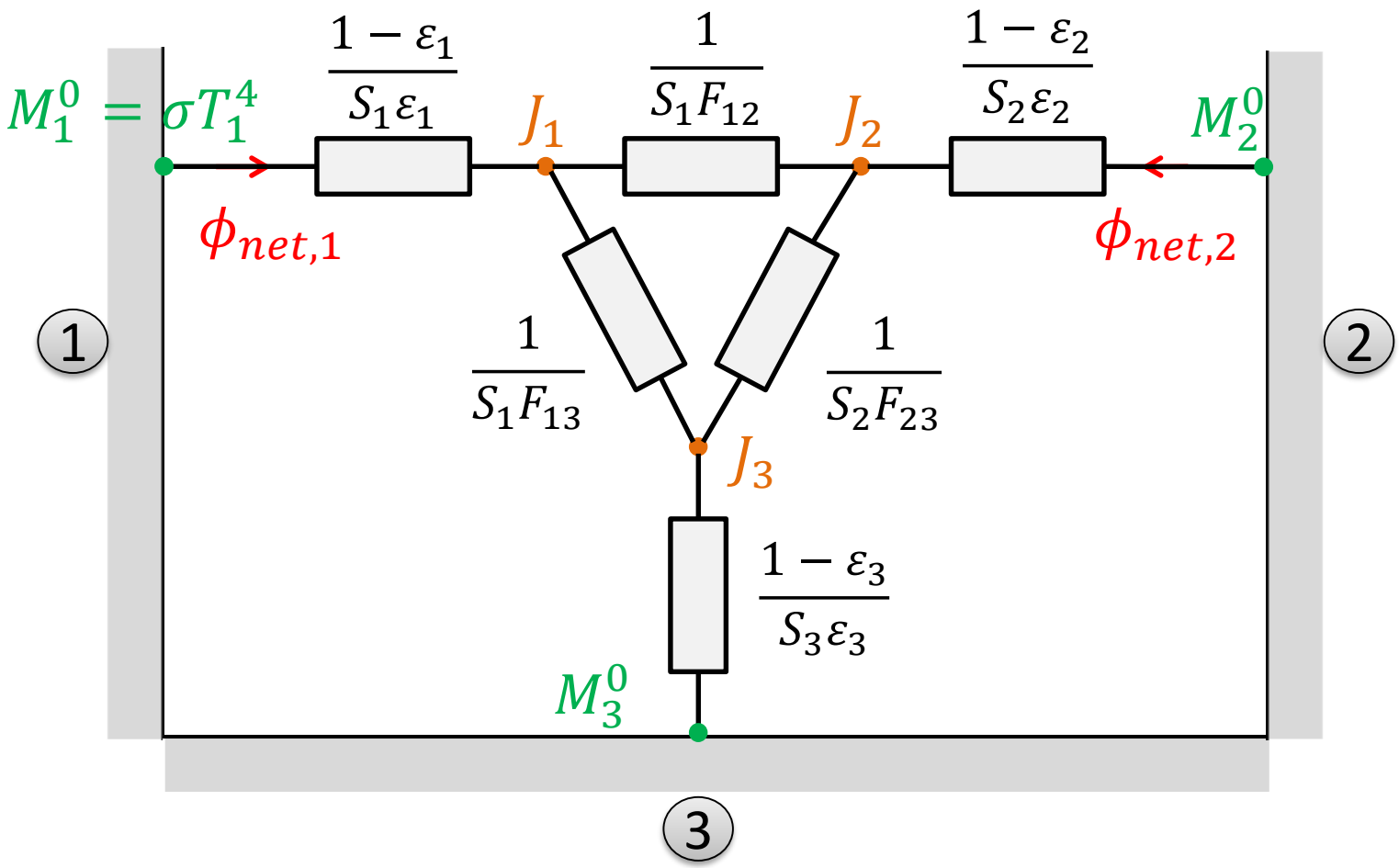
T unknown
ϕ known

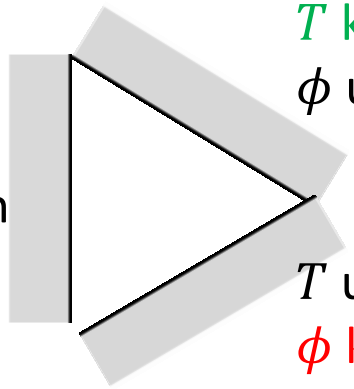
$$\phi_{net,i} = S_i \frac{\varepsilon_i}{1-\varepsilon_i}\left(\sigma T_i^4 - J_i\right)$$

$$\phi_{net,i} = \sum_j \frac{J_i - J_j}{\left(\frac{1}{S_i F_{ij}}\right)}$$

$$\phi_{net,i} = S_i \frac{\varepsilon_i}{1-\varepsilon_i}\left(\sigma T_i^4 - J_i\right)$$

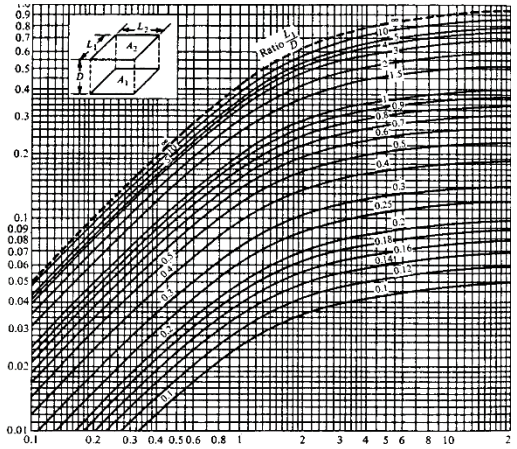
$$\phi_{net,i} = \sum_{j \neq i} \frac{J_i - J_j}{\left(\frac{1}{S_i F_{ij}}\right)}$$





1. Either the temperature or the net heat flux of heat surface is known

2. Find the view factors



$$S_1 F_{12} = S_2 F_{21}$$

$$\sum_j F_{ij} = 1$$

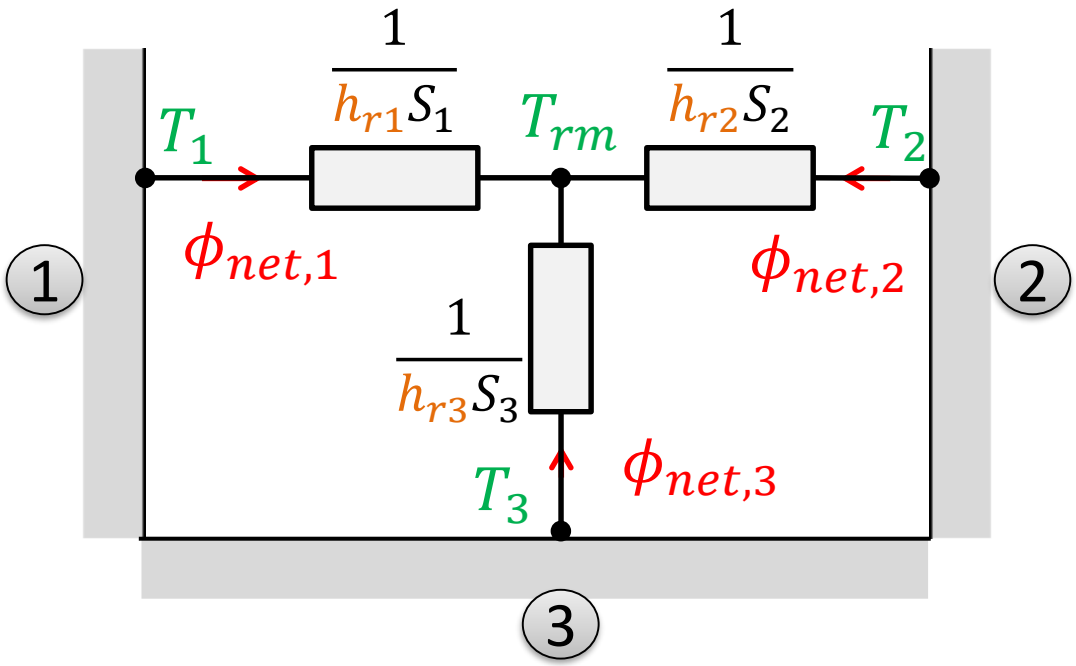
3. Solve for radiosities

$$\begin{bmatrix} 1-(1-\varepsilon_1)F_{11} & -(1-\varepsilon_1)F_{12} & -(1-\varepsilon_1)F_{13} \\ -(1-\varepsilon_2)F_{21} & 1-(1-\varepsilon_2)F_{22} & -(1-\varepsilon_2)F_{23} \\ -F_{31} & -F_{32} & 1-F_{33} \end{bmatrix} \cdot \begin{bmatrix} J_1 \\ J_2 \\ J_3 \end{bmatrix} = \begin{bmatrix} \varepsilon_1 \sigma T_1^4 \\ \varepsilon_2 \sigma T_2^4 \\ 0 \end{bmatrix}$$

4. Calculate the unknown temperatures and fluxes

Mean radiative temperature

$$T_{rm} = \left(\sum_i \frac{F_{Si}\, J_i}{\sigma} \right)^{1/4}$$



Simplified writing

$$\sum_i \phi_{net,i} = 0$$

where

$$\phi_{net,i} \approx h_{ri} S_i (T_i - T_{rm})$$

where

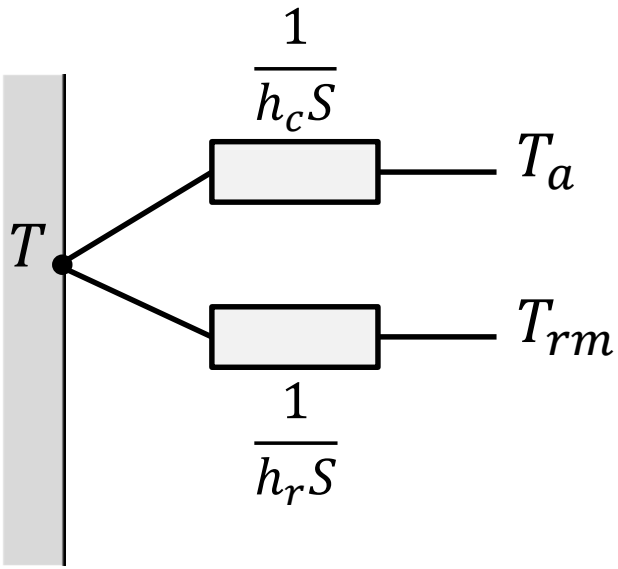
$$h_{ri} = 4 \varepsilon_i \sigma T_i^3$$

proof

F_{ij} simplified

$$\phi_{net,i} = \sigma\, \varepsilon\, S \left(T_i^4 - T_{rm}^4 \right)$$

$$T_i^4 - T_{rm}^4 = 4.T_i^3 (T_i - T_{rm})$$



Apparent temperature

$$T_{rs} = \frac{h_c T_a + h_r T_{rm}}{h_c + h_r}$$