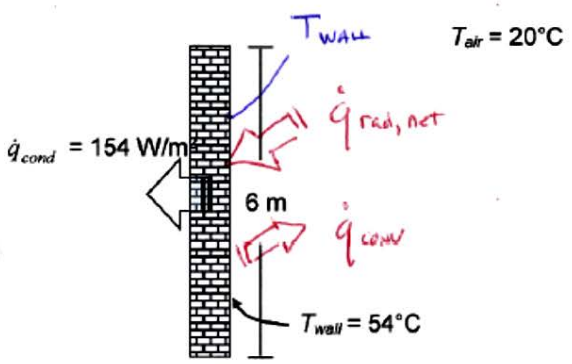
Example

The wall of a 6-m tall building is made of red brick, for which the emissivity, ε, is 0.93 and the *solar* absorptivity, α_s, is 0.63. On a sunny day, it is observed that the direct and diffuse components of solar radiation are G_D = 900 W/m² and G_d = 500 W/m², respectively, and that the sun makes a 48.2° angle with a normal to the surface of the wall. The outside temperature of the brick is 54°C, and the ambient air temperature is 20°C.

(a) Calculate the heat flux, in W/m², from the wall due to convection.
(b) If the heat flux through the brick due to conduction is 154 W/m² (into the building), what is the effective sky temperature?



(a) A good review of natural convection!
No solution here, but some highlights...

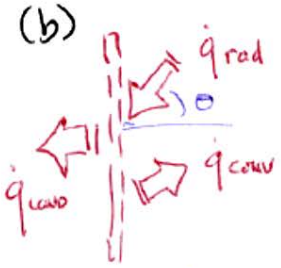
$Ra = 5.93 \times 10^{11}$

$Nu = 840$

$h = 3.75\ W/m^2 \cdot °C$

$\dot{q}_{conv} = h(T_{WALL} - T_{air}) =$ **127.6 W/m²**

(b)



Cons. of energy.

$0 = \dot{Q}_{IN,NET} + 0 + \ldots$

$0 = \dot{q}_{rad,net} A - \dot{q}_{conv} A - \dot{q}_{cond} A$

$\dot{q}_{rad,net} = \dot{q}_{cond} + \dot{q}_{conv} = 154\ W/m^2 + 127.6\ W/m^2 = 282\ W/m^2$

Also:

$$\dot{q}_{rad,net} = \alpha_s \left[G_D \cos\theta + G_d \right] + \epsilon \sigma \left[T_{SKY}^4 - T_{WALL}^4 \right]$$

$$T_{SKY} = \left[\frac{\dot{q}_{rad,net} - \alpha_s \left[G_D \cos\theta + G_d \right]}{\epsilon \sigma} + T_{WALL}^4 \right]^{1/4}$$

$$= \left\{ \frac{282 \frac{W}{m^2} - 0.63 \left(900 \frac{W}{m^2} \cos 48.2° + 500 W/m^2 \right)}{(0.93)\left(5.67 \times 10^{-8} \frac{W}{m^2 \cdot K^4}\right)} + (54+273)^4 \right\}^{1/4} =$$ **246 K**