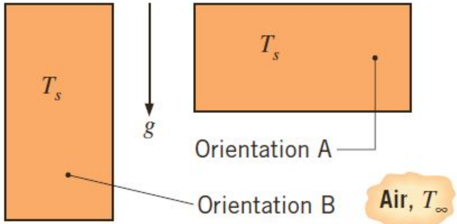
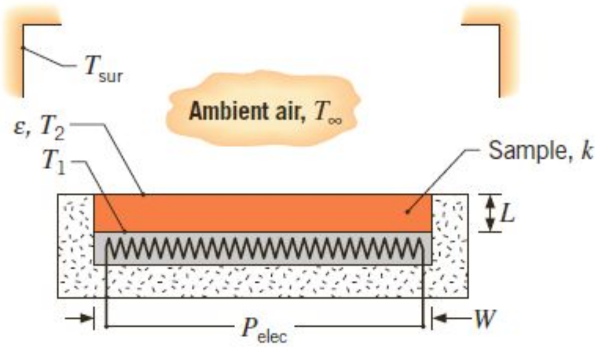
9.17 Consider a vertical plate of dimension 0.25 m × 0.50 m that is at $T_s = 100°C$ in a quiescent environment at $T_\infty = 20°C$. In the interest of minimizing heat transfer from the plate, which orientation, (A) or (B), is preferred? What is the convection heat transfer from the front surface of the plate when it is in the preferred orientation?



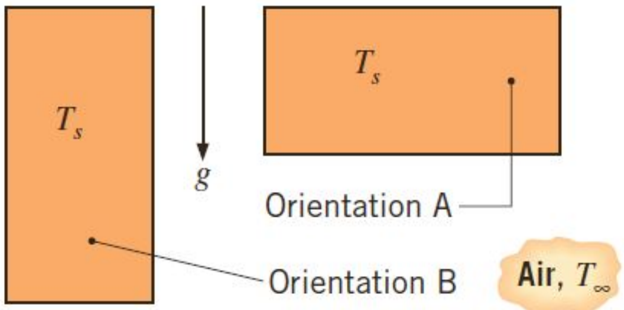
9.39 The thermal conductivity and surface emissivity of a material may be determined by heating its bottom surface and exposing its top surface to quiescent air and large surroundings of equivalent temperatures, $T_\infty = T_{sur} = 25°C$. The remaining surfaces of the sample/heater are well insulated.



Consider a sample of thickness $L = 25$ mm and a square planform of width $W = 250$ mm. In an experiment performed under steady-state conditions, temperature measurements made at the lower and upper surface of the sample yield values of $T_1 = 150°C$ and $T_2 = 100°C$, respectively, for a power input of $P_{elec} = 70$ W. What are the thermal conductivity and emissivity of the sample?

9.53 A horizontal uninsulated steam pipe passes through a large room whose walls and ambient air are at 300 K. The pipe of 150-mm diameter has an emissivity of 0.85 and an outer surface temperature of 400 K. Calculate the heat loss per unit length from the pipe.

Consider a vertical plate of dimension 0.25 m × 0.50 m that is at $T_s = 100°C$ in a quiescent environment at $T_\infty = 20°C$. In the interest of minimizing heat transfer from the plate, which orientation, (A) or (B), is preferred? What is the convection heat transfer from the front surface of the plate when it is in the preferred orientation?




```
T_air=20; % air temperature, °C

T_wall=100; % wall temperature, °C

T_film=60; % film temperature, °C

rho=1.07; % density, kg/m3

cp=1008; % specific heat, J/kgK

ni=1.851e-5; % kinematic viscosity, m2/s

alpha=2.616e-5; % thermal diffusivity, m2/s

k=0.02821; % thermal conductivity, W/mK

Pr=0.708; % Prandtl number

g=9.81; % gravitational acceleration, m/s2
```

$$\overline{Nu}_L = 0.68 + 0.67\, Ra_L^{1/4}\left[1 + \left(\frac{0.492}{Pr}\right)^{9/16}\right]^{-4/9}$$

$$Ra_L \equiv Gr_L Pr = \frac{g\beta \Delta T L^3}{\alpha \nu} \qquad (8.11)$$

ORIENTATION A

Ra = 8.6386e+07

Nu = 50.24

h = 5.67 [W/m^{2}K]

ORIENTATION B

Ra = 6.9109e+08

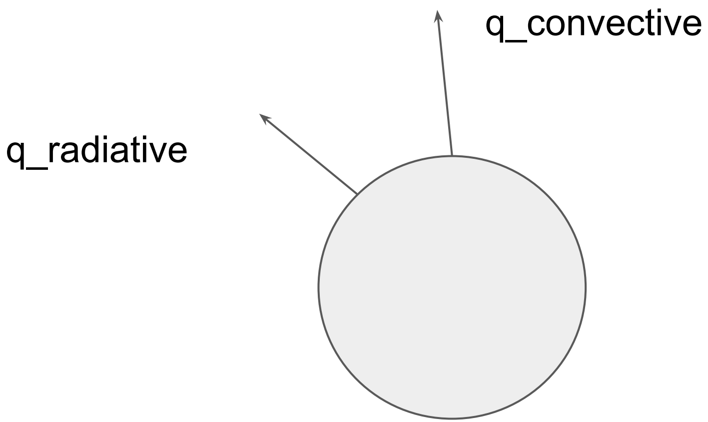
Nu = 84.03

h = 4.74 [W/m^{2}K]

9.53 A horizontal uninsulated steam pipe passes through a large room whose walls and ambient air are at 300 K. The pipe of 150-mm diameter has an emissivity of 0.85 and an outer surface temperature of 400 K. Calculate the heat loss per unit length from the pipe.

```
T_air=300; % air temperature, K
T_tube=400; % wall temperature, K
T_film=350; % film temperature, K
rho=1.008; % density, kg/m3
cp=1009; % specific heat, J/kgK
ni=2.073e-5; % kinematic viscosity, m2/s
```

```
alpha=2.931e-5; % thermal diffusivity, m2/s
k=0.02984; % thermal conductivity, W/mK
Pr=0.707; % Prandtl number
g=9.81; % gravitational acceleration, m/s2
epsilon=0.85; % emissivity
sigma=5.67e-8; % Stefan-Boltzmann constant
D=0.15; % diameter, m
```



$$\overline{Nu}_D = \left\{ 0.60 + 0.387 \left[\frac{Ra_D}{\left[1 + (0.559/Pr)^{9/16}\right]^{16/9}} \right]^{1/6} \right\}^2$$

q_radiative

$q\_radiative = \varepsilon * \sigma * (T_{tube}^4 - T_{wall}^4) =$

$= 843.4\ W/m^2$

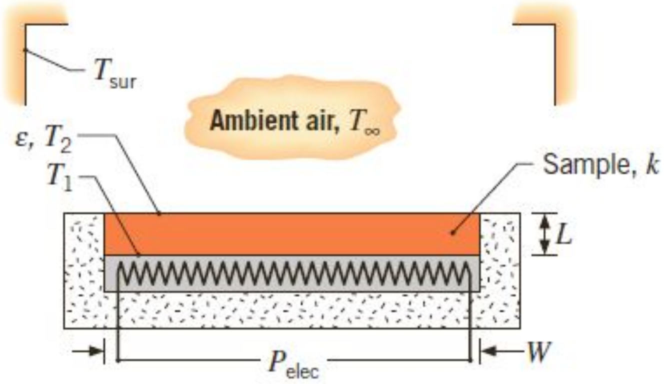
q_convective

$q\_radiative = h*(T_{tube} - T_{air}) =$

$= 316.1\ W/m^2$

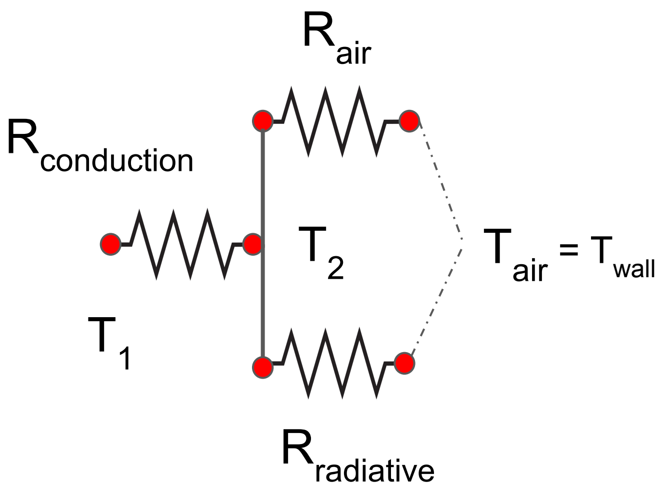
Q [per unit of length] = (q_radiative + q_convective)*π*D = 713.6 W/m

9.39 The thermal conductivity and surface emissivity of a material may be determined by heating its bottom surface and exposing its top surface to quiescent air and large surroundings of equivalent temperatures, $T_\infty = T_{sur} = 25°C$. The remaining surfaces of the sample/heater are well insulated.



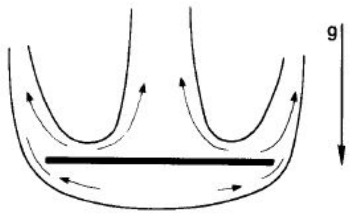
Consider a sample of thickness $L = 25$ mm and a square planform of width $W = 250$ mm. In an experiment performed under steady-state conditions, temperature measurements made at the lower and upper surface of the sample yield values of $T_1 = 150°C$ and $T_2 = 100°C$, respectively, for a power input of $P_{elec} = 70$ W. What are the thermal conductivity and emissivity of the sample?

```
T_air=25; % air temperature, °C
T_s=100; % wall temperature, °C
T_film=62.5; % film temperature, °C
rho=1.038; % density, kg/m3
cp=1009; % specific heat, J/kgK
ni=1.951e-5; % kinematic viscosity, m2/s
alpha=2.821e-5; % thermal diffusivity, m2/s
k=0.02888; % thermal conductivity, W/mK
Pr=0.707; % Prandtl number
g=9.81; % gravitational acceleration, m/s2
sigma=5.67e-8; % Stefan-Boltzmann constant
```



$$Q = (\varepsilon \cdot \sigma \cdot (T_s^4 - T_{wall}^4) + h \cdot (T_s - T_{air})) \cdot A$$

$$\varepsilon = 0.99$$



c) A hot horizontal plate ($\theta = 90°$)

Ra = 1.0946e+06

Nu = 13.8

h = 6.37 W/m2K

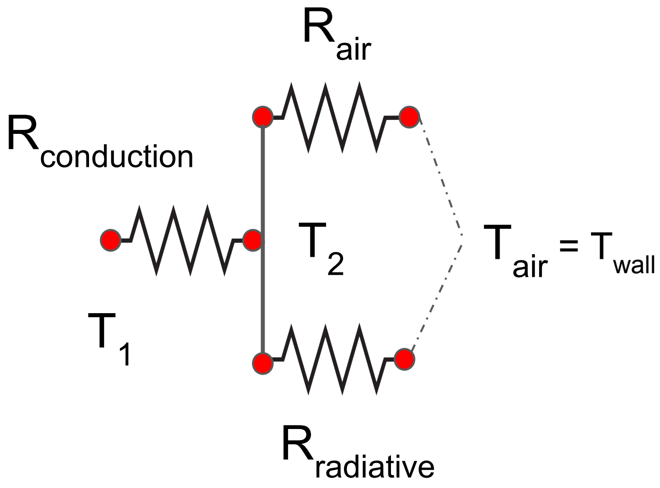
- For horizontal plates of area A and perimeter P at lower Rayleigh numbers, Raithby and Hollands suggest [8.13]

$$\overline{\mathrm{Nu}}_{L*} = \frac{0.560\,\mathrm{Ra}_{L*}^{1/4}}{\left[1 + (0.492/\mathrm{Pr})^{9/16}\right]^{4/9}} \tag{8.37a}$$

where, following Lloyd and Moran [8.22], a characteristic lengthscale $L^* = A/P$, is used in the Rayleigh and Nusselt numbers. If $\overline{\mathrm{Nu}}_{L*} \lesssim 10$, the b.l.s will be thick, and they suggest correcting the result to

$$\overline{\mathrm{Nu}}_{\mathrm{corrected}} = \frac{1.4}{\ln\left(1 + 1.4/\overline{\mathrm{Nu}}_{L*}\right)} \tag{8.37b}$$

These equations are recommended[6] for $1 < \mathrm{Ra}_{L*} < 10^7$.



Q = kA/L*(T1-T2)

k = 0.56