HW3, PP2

Tube cross-section
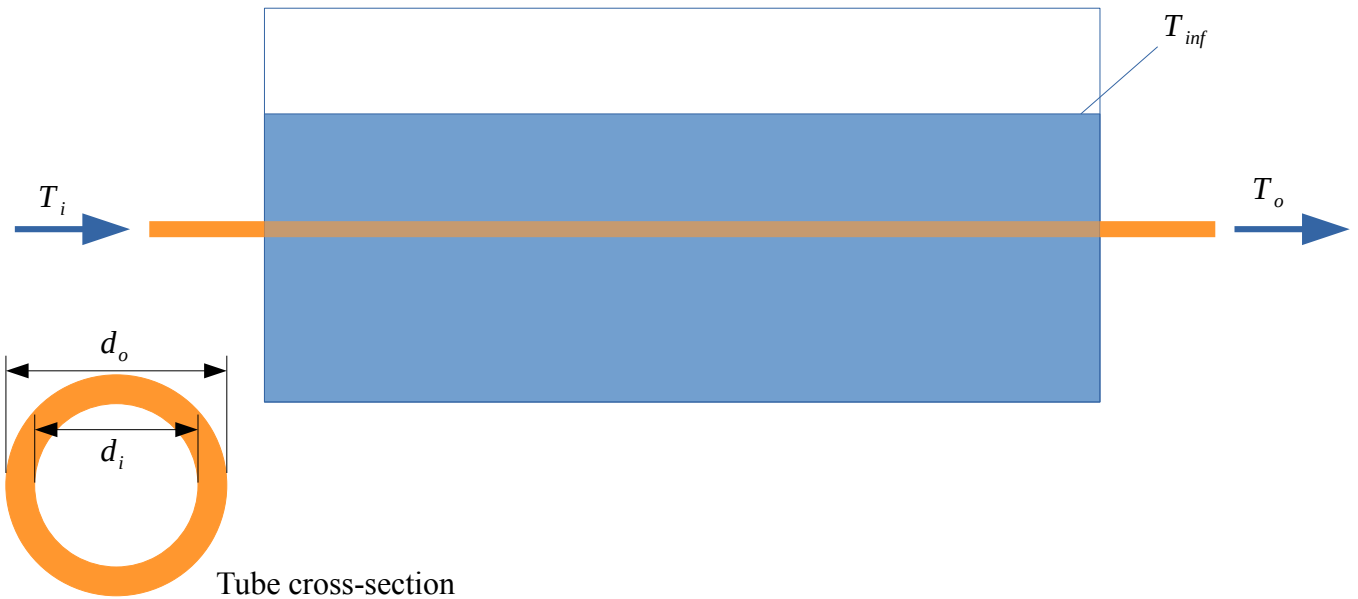
(a) calculate the rate of heat transfer

Hint: we know the flow rate and the temperature difference between the inlet and the outlet

(b) Calculate Nu and h (inside and outside of the tube) by using the given correlations. Here since we have a round tube, the characteristic lengths are the inner diameter (internal flow) and outer diameter (external flow). Calculate first the Nusselt numbers, and then use the definition of the Nusselt number to obtain h:

$$Nu = hD/k$$

The Grashof number in the natural convection correlation is

$$Gr = g\beta(T_s - T_{inf})D^3/\nu^2$$

Here we do not know what is T_s exactly since the temperature of the water in the tube is changing. We can use the average temperature of the water $T_s = (T_i + T_o)/2$ since we are considering global averages.

(c) Calculate the length of the tube

Hint: the length of the tube can be solved from the thermal resistance $q = dT_{lm}/R_{tot}$

The total thermal resistance consists of the resistance of the internal flow, the conduction through the tube walls, and the external natural convection, i.e.

$$R_{tot} = R_{internal} + R_{condiction} + R_{external}$$

For convection $R = 1/hA$

And for conduction (note that the tube is round!) $R = \ln(d_o/d_i)/2\pi k L$