Heat Transfer – 2

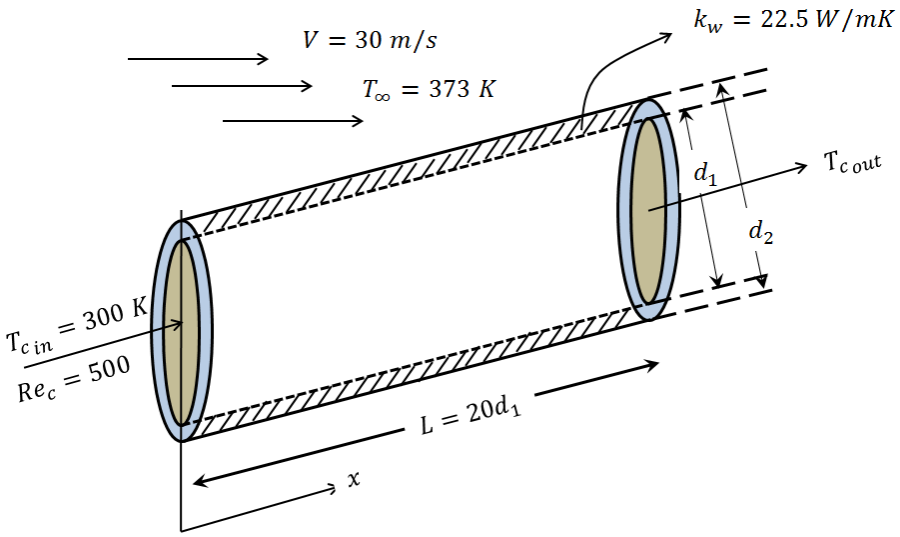
Consider a cylindrical tube with internal coolant flow and hot air flowing externally over the cylinder. The external flow velocity is 30 m/s. The Nusselt number for external heat transfer is given as

$$\overline{Nu}_{d_2} = \frac{\bar{h}d_2}{k_f} = C{Re_{d_2}}^m Pr_{ext}^{1/3}$$

Re_{d_2}	C	m
0.4-4	0.989	0.33
4-40	0.911	0.385
40-4000	0.683	0.466
4000-40,000	0.193	0.618
40,000-400,000	0.027	0.805

The constants C and m can be obtained from the table and Prandtl number is $Pr_{ext} = 0.7$.

The coolant (water) enters the tube at a temperature of 300 K. The flow in the tube can be assumed to be fully developed Laminar flow from x= 0 to x = L. The internal flow Reynolds number is 500. The Nusselt number for the internal flow is 20.



$$d_1 = 2.54\ cm, d_2 = 1.1d_1.$$

$$Internal\ flow: \rho_c = 996\ \frac{kg}{m^3}, \mu_c = 0.008508 \frac{kg}{ms}, k_c = 0.61 \frac{W}{mK}, c_p = 4.180 \frac{J}{gK}$$

$$External\ flow: \rho_{air} = 0.9413\ \frac{kg}{m^3}, \mu_{air} = 2.181\times10^{-5}\ \frac{kg}{ms}, k_{air} = 0.03186\ W/mK$$

(a) Find the required heat transfer coefficients and the overall heat transfer coefficient. (10 points)

(b) Find the expression for the coolant temperature as a function of x and sketch the fluid temperatures as a function of x. (35 points)

(c) Find the coolant exit temperature ($T_{c\,out}$). (15 points)

(d) Find the heat flux as a function of x and sketch the heat flux as a function of x. (25 points)
Find the overall heat transfer to the fluid. (15 points)