Homework 1

Question 1

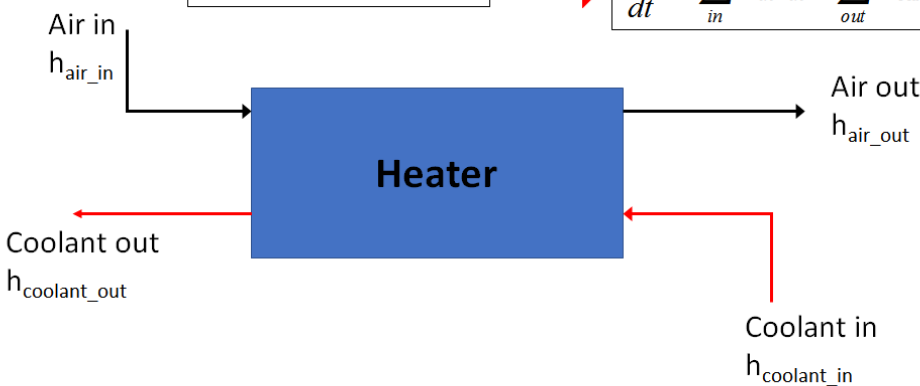
Temperatures are all expresed in degree Celciusb but to have consistent results in MathCad, the are writing in Kelvin, since the calculation of entalphies are based o temperatures differences, results are the same if we express temperatures in either Kelvins or Celsius

$T_{air\_out} := 30 \cdot K$ $\quad T_{air\_in} := -10 \cdot K$ $\quad T_{coolant\_in} := 85 \cdot K$ $\quad T_{coolant\_out} := 45 \cdot K$

$V_{air} := 30 \cdot \frac{m^3}{min}$ $\quad kJ := 1000 \cdot J$ $\quad C_{p\_air} := 1 \cdot \frac{kJ}{kg \cdot K}$ $\quad C_{p\_coolant} := 3.3 \cdot \frac{kJ}{kg \cdot K}$

$\rho_{air} := 1.2 \cdot \frac{kg}{m^3}$

$$\boxed{\dot{E}_{in} - \dot{E}_{out} + \dot{E}_{gen} = \dot{E}_{st}} \Rightarrow \boxed{\frac{dU}{dt} = \sum_{in} \dot{m}_{in} h_{in} - \sum_{out} \dot{m}_{out} + \dot{Q} + \dot{W}_s}$$



$$\sum_{in} \dot{m}_{in} h_{in} - \sum_{out} \dot{m}_{out} h_{out} \Rightarrow \dot{m}_{air} h_{air\_in} + \dot{m}_{coolant} h_{coolant\_in} = \dot{m}_{air} h_{air\_out} + \dot{m}_{coolant} h_{coolant\_out}$$

The equation above is obtained by considering state state dU/dt = 0, adiabatic process or not heat loss Q=0 (so it is not a energy transport problem) and shaft work W_s = 0. Specific enthalpy can be calculated as h = Cp T with units kJ/kg, if T_{ref} is assumed to be 0^oC

$m_{air} := V_{air} \cdot \rho_{air}$ $\quad m_{air} = 36 \cdot \frac{kg}{min}$

$$m_{coolant} := \frac{m_{air} \cdot C_{p\_air} \cdot (T_{air\_out} - T_{air\_in})}{C_{p\_coolant} \cdot (T_{coolant\_in} - T_{coolant\_out})} \qquad \boxed{m_{coolant} = 10.9 \cdot \frac{kg}{min}}$$

Question 2

$d_{plyw} := 1 \cdot in$ $\quad T_1 := 100 \cdot F$ $\quad T_2 := 50 \cdot F$

$$k_{plyw} := 0.070 \cdot \frac{BTU}{hr \cdot ft \cdot F}$$

Assumptions
- 1D heat flow
- Steady State
- No Convection
- No heat generation

Definetely is a energy transfer process so we can use the equations derived in class for the Flux

$$Flux := k_{plyw} \cdot \frac{T_1 - T_2}{d_{plyw}} \qquad \boxed{Flux = 42 \cdot \frac{BTU}{hr \cdot ft^2}}$$

Question 3

(a)
(1) two boundary conditions in x and y and one initial condition
(2) T(x,y,t)
(3) The equation assumes no convection and no heat genration
(4) The model is assuming Cartesian coordinates

(b)
(1) two boundary conditions in r
(2) T(r)
(3) The equation assumes no convection, no heat heat generation and steady state
(4) The model is assuming cylindrical coordiates

(c)
(1) One boundary condition in x and two boundary condtions in y
(2) T(x,y)
(3) The equation no heat generation, 1D conduction in direction y and and steady state
(4) The model is assuming Cartesian Coordinates

Question 4

Straight forward proof

Question 5

$m_p := 85$ $\quad h_p := 1.80$ $\quad A_p := 2.5$ $\quad u_p := 1.1$

$h := 25$ $\quad T_{air} := 22 + 273$ $\quad \sigma := 5.676 \cdot 10^{-8}$

Balance of Energy is:

Energy In - Energy Out + Generation =Storage

Let's assume steady state so storage = 0

Energy_in=0

Energy Out=$hA(T_s-T_w)+\sigma A(T_s^4-T_w^4)+0.12u_p x13.3xexp(20.4-5132/T_s)=0$

Generation=$4m_pu_p$

We can use the balance of Energy and construct an equation to estimate T_s

$$f(T_S) := 4\cdot m_p\cdot u_p - h\cdot A_p\cdot(T_S - T_{air}) - \left[\sigma\cdot A_p\cdot\left(T_S{}^4 - T_{air}{}^4\right) + 0.12\cdot u_p{}^{0.5}\cdot A_p\cdot\left[13.3\cdot\left(e^{20.4-\frac{5132}{T_S}} - 0\right)\right]\right]$$

$$T_S := 300$$

$$T_{Sol} := \mathrm{root}(f(T_S), T_S) \qquad T_{Sol} = 298.499$$

$$\mathrm{Temp\_of\_body} := T_{Sol} - 273 \qquad \boxed{\mathrm{Temp\_of\_body} = 25.5}$$ In Celsius

(b) We can assume that in order to keep stady state all the heat generated by the person must be lost so:

$$h_{eff} := \frac{4\cdot m_p\cdot u_p}{A_p\cdot[26 - (T_{air} - 273)]}$$

$\boxed{h_{eff} = 37.4}$ Units are W/m2