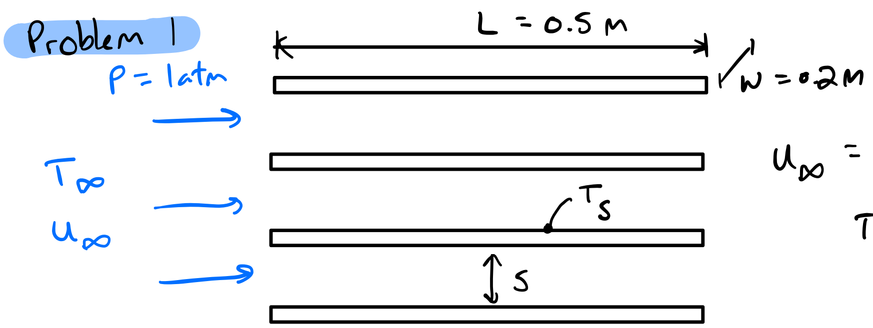
Problem 1



$u_\infty = 50\ m/s,\ T_\infty = 10°C$

$T_s = 200°C$

a) s s.t. external flow, find $\dot{q}$ for single plate, both sides

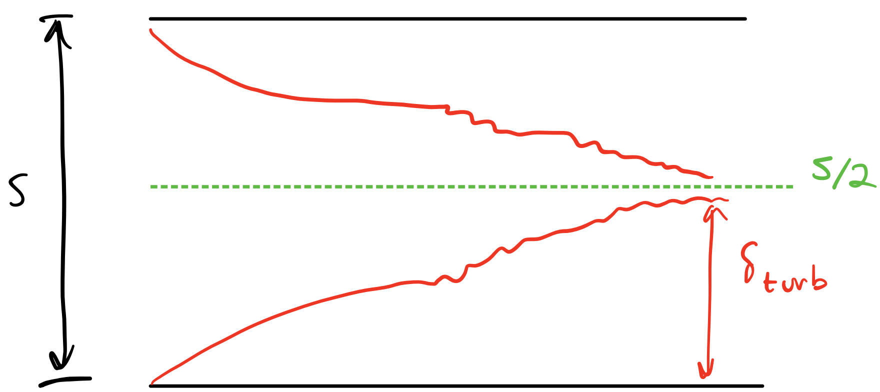
$\dot{q}_{2s} = 2 \cdot \dot{q}_{1s}$

$T_{film} = \frac{T_s + T_\infty}{2} = 378.15\ [K]$

$Re_{crit} = \frac{\rho u_\infty x_{crit}}{\mu} = 5e5 \rightarrow x_{crit} = 0.2359\ [m] < L = 0.5\ [m]$

$\rightarrow$ laminar & turbulent correlations

b)



$\rightarrow s_{min} = 2 \cdot \delta_{turb}$

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$unitsystem SI C J Pa

"Problem 1"
L = 0.5 [m]
W = 0.2[m]
u_infinity = 50 [m/s]
T_infinity = 10 [C]
T_s = 200 [C]
P = 1 [atm]*convert(atm,Pa)
A_s = L*W

T_film = (T_s+T_infinity)/2

Re_crit = 5e5
Re_crit = rho*u_infinity*x_crit/mu
rho = density(Air,T=T_film,P=P)
mu = viscosity(Air,T=T_film)

"part a correlation"
Re_L = rho*u_infinity*L/mu
Pr = prandtl(Air,T=T_film)

Nus_bar_L = 0.6774*Pr^(1/3)*Re_crit^0.5 / ( 1+(0.0468/Pr)^(2/3) )^(1/4)  +  0.0158*Pr^(1/3)* ( Re_L^(6/7)-Re_crit^(6/7) ) "use laminar and turblent correlation since xcrit<L"

Nus_bar_L = h_bar*L/k
k = conductivity(Air,T=T_film)

q_dot_oneside = h_bar*A_s*(T_s-T_infinity)
q_dot_total = 2*q_dot_oneside

"part b"
delta_turb = 0.16*L/Re_L^(1/7)          "max thickness at end of plate, s needs to be at least twice this value for external flow"

s = delta_turb*2
```

SOLUTION

Unit Settings: SI C Pa J mass deg

A_s = 0.1 [m^2]	δ_{turb} = 0.01102 [m]	$\overline{h}$ = 86.99 [W/m^2-K]	k = 0.0313 [W/m-K]
L = 0.5 [m]	μ = 0.00002202 [Pa-S]	$\overline{Nus}_L$ = 1390 [-]	P = 101325 [Pa]
Pr = 0.711 [-]	$\dot{q}_{oneside}$ = 1653 [W]	$\dot{q}_{total}$ = 3306 [W]	Re_{crit} = 500000 [-]
Re_L = 1.060E+06 [-]	ρ = 0.9335 [kg/m^3]	s = 0.02205 [m]	T_{film} = 105 [C]
T_∞ = 10 [C]	T_s = 200 [C]	u_∞ = 50 [m/s]	W = 0.2 [m]
x_{crit} = 0.2359 [m]			

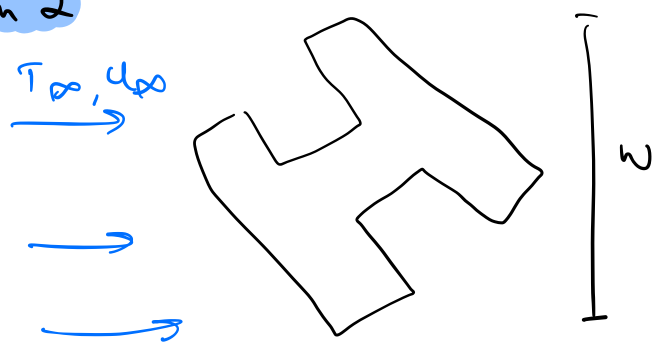
No unit problems were detected.

KEY VARIABLES

$\dot{q}_{total}$ = 3306 [W]	*a) total heat transfer from single plate, both sides*
s = 0.02205 [m]	*b) minimum spacing s such that boundary layers do not touch by the end of the length*

Problem 2

$per = 2.1 \cdot W$



$$Nu = a_0 \cdot Re_L^{a_1} \cdot Pr^{a_2}$$

```
$unitsystem SI C J Pa
$tabstops 0.2 0.4 0.6 1.5

"
Starter file.

Homework 7 - correlation problem
ME 364 - Fall 2023"

$varinfo u_infty[] units='m/s'
$varinfo rho[] units='kg/m^3'
$varinfo mu[] units='Pa-s'
$varinfo c[] units='J/kg-K'
$varinfo k[] units='W/m-K'
$varinfo current[] units='A'
$varinfo voltage[] units='V'
$varinfo T_infty[] units='C'
$varinfo T_s[] units='C'

"Geometry"
L = 0.5 [m]  "Length of structure"
W = 0.075 [m]                "Profile width in flow"
per = 2.1 * W                "Perimeter of the shape"
A_s = per*L                  "Surface area - ignore ends"

N_lookup = 30                "Rows in the lookup table"

"! To inspect data, go to Lookup table window"

"Retrieve table data as arrays"
Duplicate i=1,N_lookup
    u_infty[i] = lookup('data', i, 'u_infty')
    rho[i] = lookup('data', i, 'rho')
    mu[i] = lookup('data', i, 'mu')
    c[i] = lookup('data', i, 'c')
    k[i] = lookup('data', i, 'k')
    current[i] = lookup('data', i, 'current')
    voltage[i] = lookup('data', i, 'voltage')
    T_infty[i] = lookup('data', i, 'T_infty')
    T_s[i] = lookup('data', i, 'T_s')

    "...Calculations here..."
    ReL[i] =  rho[i]*u_infty[i]*L/mu[i]
    Pr[i] = mu[i]*c[i]/k[i]
    q_dot[i] = current[i]*voltage[i]
    q_dot[i] = h_bar[i]*A_s*(T_s[i]-T_infty[i])
    Nu_bar[i] = h_bar[i]*L/k[i]

    Nu_p[i] = a0 * (rho[i]*u_infty[i]*L/mu[i])^(a1) * (mu[i]*c[i]/k[i])^(a2)

    "error"
    err[i] = abs(Nu_p[i]-Nu_bar[i])/Nu_bar[i]

 End

{a0 = 1
a1 = 1
```

a2 = 1}

"Cumulative error"
err_tot = sum(err[i],i=1,30)

"part c"

"Yes, the predictied Nusselt number values closely match the experimental data, indicating a good correlation with these coefficients."

SOLUTION
Unit Settings: SI C Pa J mass deg
Minimization of err_tot(a0,a1,a2) 806 iterations: Variable Metric method (Rel. Tol=1.0E-06)

a0 = 1.207 [-]	a1 = 0.3408 [-]	a2 = 0.491 [-]	A_s = 0.07875 [m^2]	err_{tot} = 1.994 [-]
L = 0.5 [m]	N_{lookup} = 30 [-]	per = 0.1575 [m]	W = 0.075 [m]	

No unit problems were detected.

KEY VARIABLES
Minimization of err_tot(a0,a1,a2) 806 iterations: Variable Metric method (Rel. Tol=1.0E-06)
a0 = 1.207 [-] *b) a0 coefficient*
a1 = 0.3408 [-] *b) a1 coefficient*
a2 = 0.491 [-] *b) a2 coefficient*