Homework 10

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Problem 1

We know that Heat transfred by the plate must equal heat by free convection so we will calculate both with a estimation and ajust the value of T_s tell they are equal.

```
%Givens
leng=0.2; %meters long
thick = 25/1000; %meters thick
k_plate = 15; %W/m k
T_hot = 100 + 303; %temp in K
T_cold = 7+ 303; %temp in K
T_surG1 = 53.5+303;%temp in K T_surG1 = 344.2; %
%constants
g =9.81;

%Find Ra_l first
T_film = (T_surG1+T_cold)/2;
%From tables A-15
beta = 0.294*(10^-3);
Pr = 5.42;
mu = 0.798*(10^-3);
rho = 996;
v = mu/rho;
k_water = 0.615;

Ra_l = g*beta*(T_surG1-T_cold)*(leng^3)*Pr/(v^2);
Nu = (0.825+((0.387*(Ra_l^(1/6)))/((1+((0.492/Pr)^(9/16)))^(8/27))))^2;

h = k_water*Nu/leng;

%Assume A = 1
Q_conv=h*(T_surG1-T_cold)
```

```
Q_conv = 4.2931e+04
```

```
Q_cond = k_plate*(T_hot-T_surG1)/thick
```

```
Q_cond = 27900
```

```
(Q_conv>Q_cond)
```

```
ans = logical
   1
```

```
Q_conv-Q_cond
```

```
ans = 1.5031e+04
```

```
T_surG2 = (T_surG1+T_cold)/2;

%Find Ra_l first
T_film = (T_surG2+T_cold)/2;
T_film - 303
```

```
ans = 18.6250
```

```
%From tables A-15 20
beta = 0.195*(10^-3);
Pr = 7.01;
mu = 1.002*(10^-3);
rho = 998;
v = mu/rho;
k_water = 0.598;

Ra_l = g*beta*(T_surG2-T_cold)*(leng^3)*Pr/(v^2)
```

```
Ra_l = 2.4743e+09
```

```
Nu = (0.825+((0.387*(Ra_l^(1/6)))/((1+((0.492/Pr)^(9/16)))^(8/27))))^2;

h = k_water*Nu/leng;

%Assume A = 1
Q_conv=h*(T_surG2-T_cold)
```

```
Q_conv = 1.4075e+04
```

```
Q_cond = k_plate*(T_hot-T_surG2)/thick
```

```
Q_cond = 41850
```

```
(Q_conv>Q_cond)
```

```
ans = logical
   0
```

```
Q_conv-Q_cond
```

```
ans = -2.7775e+04
```

```
T_surG3 = (T_surG1+T_surG2)/2;
T_film = (T_surG3+T_cold)/2;
T_film - 303
```

```
ans = 24.4375
```

```
%From tables A-15 25C
beta = 0.247*(10^-3);
Pr = 6.14;
mu = 0.891*(10^-3);
rho = 997;
```

```
v = mu/rho;
k_water = 0.607;

Ra_l = g*beta*(T_surG3-T_cold)*(leng^3)*Pr/(v^2)
```

```
Ra_l = 5.1972e+09
```

```
Nu = (0.825+((0.387*(Ra_l^(1/6)))/((1+((0.492/Pr)^(9/16)))^(8/27))))^2;

h = k_water*Nu/leng;

%Assume A = 1
Q_conv=h*(T_surG3-T_cold)
```

```
Q_conv = 2.6863e+04
```

```
Q_cond = k_plate*(T_hot-T_surG3)/thick
```

```
Q_cond = 34875
```

```
(Q_conv>Q_cond)
```

```
ans = logical
   0
```

```
Q_conv-Q_cond
```

```
ans = -8.0124e+03
```

```
T_surG4 = (T_surG3+T_surG1)/2;
T_film = (T_surG4+T_cold)/2 - 303
```

```
T_film = 27.3438
```

```
%From tables A-15 25
beta = 0.247*(10^-3);
Pr = 6.14;
mu = 0.891*(10^-3);
rho = 997;
v = mu/rho;
k_water = 0.607;

Ra_l = g*beta*(T_surG4-T_cold)*(leng^3)*Pr/(v^2)
```

```
Ra_l = 6.0635e+09
```

```
Nu = (0.825+((0.387*(Ra_l^(1/6)))/((1+((0.492/Pr)^(9/16)))^(8/27))))^2;

h = k_water*Nu/leng;

%Assume A = 1
```

```
Q_conv=h*(T_surG4-T_cold)
```

```
Q_conv = 3.2905e+04
```

```
Q_cond = k_plate*(T_hot-T_surG4)/thick
```

```
Q_cond = 3.1388e+04
```

```
(Q_conv>Q_cond)
```

```
ans = logical
   1
```

```
Q_conv-Q_cond
```

```
ans = 1.5180e+03
```

```
T_surG4-303
```

```
ans = 47.6875
```

```
T_surG5 = (T_surG4+T_surG3)/2;
T_film = (T_surG5+T_cold)/2 - 303
```

```
T_film = 25.8906
```

```
%From tables A-15 25
beta = 0.247*(10^-3);
Pr = 6.14;
mu = 0.891*(10^-3);
rho = 997;
v = mu/rho;
k_water = 0.607;

Ra_l = g*beta*(T_surG5-T_cold)*(leng^3)*Pr/(v^2)
```

```
Ra_l = 5.6304e+09
```

```
Nu = (0.825+((0.387*(Ra_l^(1/6)))/((1+((0.492/Pr)^(9/16)))^(8/27))))^2;

h = k_water*Nu/leng;

%Assume A = 1
Q_conv=h*(T_surG5-T_cold)
```

```
Q_conv = 2.9847e+04
```

```
Q_cond = k_plate*(T_hot-T_surG5)/thick
```

```
Q_cond = 3.3131e+04
```

```
(Q_conv>Q_cond)
```

```
ans = logical
   0
```

```
Q_conv-Q_cond
```

```
ans = -3.2842e+03
```

```
T_surG5-303
```

```
ans = 44.7813
```

Final Temp 46.23 degrees after 5 iterations

Problem 2

```
Length = 0.15; %Meters
Width = 0.2; %Meters
Area = Length*Width;
T_room = 20+303; %Room temp in K
Power = 8; %Watts steady consumption

%Assume film is 32.5 C
beta = 1/(32.5+303);
Pr = 0.7268;
mu = 1.895*(10^-5);
v = 1.655*(10^-5);
k_air = 0.02625;
epslon = 0.8;
sigma = 5.670373*(10^-8);

%a.)

T_G1 = 303+50; %Starting with 50C we iterated to find new value

Ra_l = g*beta*(T_G1-T_room)*(Width)*Pr/(v^2);

Nu = (0.825+((0.387*(Ra_l^(1/6)))/((1+((0.492/Pr)^(9/16)))^(8/27))))^2;

h = k_air*Nu/Width;

Q_remaining = ((sigma*epslon*Area*((T_G1^4)-(T_room^4)))+(h*Area*(T_G1-T_room)))-8
```

```
Q_remaining = 9.8313
```

```
T_G1 = 303+35.6; %Starting with 50C we iterated to find new value

Ra_l = g*beta*(T_G1-T_room)*(Width)*Pr/(v^2);

Nu = (0.825+((0.387*(Ra_l^(1/6)))/((1+((0.492/Pr)^(9/16)))^(8/27))))^2;

h = k_air*Nu/Width;

Q_remaining = ((sigma*epslon*Area*((T_G1^4)-(T_room^4)))+(h*Area*(T_G1-T_room)))-8
```

```
Q_remaining = -0.0170
```

Finds T surface is 36.6 C by iterating tthroguht values of T surface.

```
%b.)


T_G1 = 303+50; %Starting with 50C we iterated to find new value

Ra_l = g*beta*(T_G1-T_room)*(Length^3)*Pr/(v^2);

Nu = (0.825+((0.387*(Ra_l^(1/6)))/((1+((0.492/Pr)^(9/16)))^(8/27))))^2;

h = k_air*Nu/Length;

Q_remaining = ((sigma*epslon*Area*((T_G1^4)-(T_room^4)))+(h*Area*(T_G1-T_room)))-8
```

```
Q_remaining = 2.9232
```

```

T_G1 = 303+43; %Starting with 50C we iterated to find new value

Ra_l = g*beta*(T_G1-T_room)*(Length^3)*Pr/(v^2);

Nu = (0.825+((0.387*(Ra_l^(1/6)))/((1+((0.492/Pr)^(9/16)))^(8/27))))^2;

h = k_air*Nu/Length;

Q_remaining = ((sigma*epslon*Area*((T_G1^4)-(T_room^4)))+(h*Area*(T_G1-T_room)))-8
```

```
Q_remaining = -0.0326
```

Finds T surface is 43 C by iterating tthroguht values of T surface.

```
%c.)
T_G1 = 303+38.5; %Starting with 50C we iterated to find new value

Ra_l = g*beta*(T_G1-T_room)*(Length^3)*Pr/(v^2);

Nu = 0.27*(Ra_l^(1/4));

h = k_air*Nu/(Area/(2*(Length+Width)));

Q_remaining = ((sigma*epslon*Area*((T_G1^4)-(T_room^4)))+(h*Area*(T_G1-T_room)))-8
```

```
Q_remaining = 0.0025
```

Finds T surface is 38.5 C by iterating tthroguht values of T surface.

The 32.5 degree film is not the best but is acceptable for an inital analysis.

Problem 3

```
n=.1; %Bulb efficancy
power = 60; %Power into system
```

```
emis = .9; %
T_room = 303+25;
d = 0.08;
A = 4*pi*((d/2)^2);

T = 157+303; %Stated 200, then 161, 157

T_film = (T+T_room)/2
```

```
T_film = 394
```

```
beta = 1/(T_film);
Pr = 0.7132
```

```
Pr = 0.7132
```

```
v = 2.139*(10^-5);
k_air = 0.03024;

Ra_d =g*beta*(T-T_room)*(d^3)*Pr/(v^2);

Nu = 2 + (0.589*(Ra_d^(1/4)))/((1+((0.469/Pr)^(9/16)))^(4/9));

h = k_air*Nu/d;

Q = (power*(1-n))-(sigma*emis*A*((T^4)-(T_room^4)))-(h*A*(T-T_room))
```

```
Q = -0.4313
```

Final temp is 157 degrees C.