\[
U\text{-}\text{channel heat sink}
\]

\[
\begin{align*}
T_1 &= (T_{in} + T_{surface}) / 2 \\
P_1 &= 101 \\
rho_1 &= \text{Density}(\text{Air}, T = T_1, P = P_1) \\
\mu_1 &= \text{Viscosity}(\text{Air}, T = T_1) \\
cp_1 &= C_p(\text{Air}, T = T_1) \\
cv_1 &= C_v(\text{Air}, T = T_1) \\
Pr_1 &= \text{Prandtl}(\text{Air}, T = T_1) \\
k_1 &= \text{Conductivity}(\text{Air}, T = T_1)
\end{align*}
\]

\[
V = 1 \\
T_{in} = 300 \\
\text{channelwidth} = 0.007 \\
\text{channelheight} = 0.03 \\
\text{channellength} = 0.03 \\
\text{numberchannels} = 4 \\
\text{finthickness} = 0.001 \\
T_{surface} = 320
\]

\[
\text{[now find } R_{conv} \text{]} \\
D_h = 4 \times \frac{A_c}{P} \\
A_c = \text{channelheight} \times \text{channelwidth} \\
P = 2 \times \text{channelheight} + 2 \times \text{channelwidth} \\
Re = \frac{V \times D_h}{\rho_1 \mu_1}
\]

hydroentrylength = 0.075 \times Re \times Dh \\
thermalentrylength = 0.054 \times Re \times Dh \times Pr_1

\[
\text{[developing both thermally and hydrodynamically]} \\
Gz_{inverse} = \text{channellength} / \text{Dh} / \text{Re} / \text{Pr}_1
\]

\[
\text{[look at figure from handout]} \\
Nu = 15 \quad \text{(just a rough number)} \\
\text{Use } Nu = 3.16e + \ldots \text{ equation}
\]

\[
\begin{align*}
Nu &= h \times Dh / k_1 \\
R_{conv} &= 1 / h / A_{surface} \\
A_{surface} &= \text{channelheight} \times \text{channellength} + 2 \times \text{numberchannels} + \text{channellength} \times \text{channelwidth} \times \text{numberchannels}
\end{align*}
\]

\text{SOLUTION}

Unit Settings: [J]/[K]/[kPa]/[kg]/[degrees]

\[
\begin{align*}
A_c &= 0.00021 \quad [-] \\
\text{channelheight} &= 0.03 \\
\text{channelwidth} &= 0.007 \\
cv_1 &= 716.2 \quad [J/kg-K] \\
\text{finthickness} &= 0.001 \\
h &= 34.87 \quad [W/m-K] \\
k_1 &= 0.02639 \quad [W/m-K] \\
V &= 15 \quad [m^2/KW] \\
P &= 0.074 \quad [-] \\
P_1 &= 101 \\
R_e &= 676.8 \quad [-] \\
\text{thermalentrylength} &= 0.3009 \quad [m] \\
T_{surface} &= 320 \\
\text{Asurface} &= 0.00804 \quad [-] \\
\text{channellength} &= 0.03 \\
cp_1 &= 1005 \quad [J/kg-K] \\
D_h &= 0.01135 \quad [m] \\
Gz_{inverse} &= 0.005384 \quad [-] \\
\text{hydroentrylength} &= 0.5762 \quad [m] \\
\mu_1 &= 0.00001904 \quad [kg/m-s] \\
\text{numberchannels} &= 4 \\
Pr_1 &= 0.7252 \quad [-] \\
R_{conv} &= 3.567 \quad [-] \quad \text{°C/W} \\
p_1 &= 1.135 \quad [kg/m^2] \\
T_{in} &= 300 \\
T_1 &= 310 \quad [-]
\end{align*}
\]
**pin fin homework problem**

**knowns**
- Tin = 300
- Patm = 101
- V = 1
- St = 0.01
- Sl = 0.01
- D = 0.0015
- height = 0.03
- numbertubes = 23
- Ts = 320

**properties**
- rho = Density(Air, T=Tin, P=Patm) \(\text{only a small change in temp from inlet to outlet, so OK to use Tin}\)
- mu = Viscosity(Air, T=Tin)
- Pr = Prandtl(Air, T=Tin)
- Prs = Prandtl(Air, T=Ts)
- k = Conductivity(Air, T=Tin)

**equations**
- Re = rho * Vmax * D / mu
- Vmax = St / (St / D)^V
- Sd = (St / D)^2 + (St / D)^2 * 0.6
- \(\text{Nu} = F \times 1.04 \times Re^{0.4} \times Pr^{0.36} \times (Pr/Prs)^{0.25}\)
- F = 0.93 \(\text{correction factor because we have fewer than 16 columns}\)
- Nu = h * D / k
- Rconv = 1 / h / Asurface
- Asurface = Atubes + Abase \(\text{here we're using an estimate that h for the base is the same as h for the tubes. It probably will actually be somewhat less}\)
- Atubes = pi * D * height * numbertubes
- Abase = width * length
- width = length
- width = 4 * st + D + 0.01 \(\text{calculate from fin pitch plus how far the base extends past the last fin on each side}\)

**SOLUTION**

Unit Settings: [kJ] / [kJ] / [kPa] / [kg] / [degrees]

<table>
<thead>
<tr>
<th>Abase</th>
<th>0.002652 [-]</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>0.0015</td>
</tr>
<tr>
<td>height</td>
<td>0.03</td>
</tr>
<tr>
<td>(\mu)</td>
<td>0.00001857 [kg/m-s]</td>
</tr>
<tr>
<td>Patm</td>
<td>101</td>
</tr>
<tr>
<td>Rconv</td>
<td>2.419 [(\bullet\C/w)]</td>
</tr>
<tr>
<td>Sd</td>
<td>0.01118</td>
</tr>
<tr>
<td>Tin</td>
<td>300</td>
</tr>
<tr>
<td>Vmax</td>
<td>0.5165 [-]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Asurface</th>
<th>0.005904 [-]</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>0.93</td>
</tr>
<tr>
<td>k</td>
<td>0.02665 [W/m-K]</td>
</tr>
<tr>
<td>v</td>
<td>4.096 [m-K/W]</td>
</tr>
<tr>
<td>Pr</td>
<td>0.7278 [-]</td>
</tr>
<tr>
<td>Re</td>
<td>48.93 [s/m²]</td>
</tr>
<tr>
<td>Sl</td>
<td>0.01</td>
</tr>
<tr>
<td>Ts</td>
<td>320</td>
</tr>
<tr>
<td>width</td>
<td>0.0515 [-]</td>
</tr>
</tbody>
</table>

\(\text{Atubes} = 0.003252 [-]\)

\(\text{h} = 70.03 \text{ W/m-k}\)

<table>
<thead>
<tr>
<th>length</th>
<th>0.0515</th>
</tr>
</thead>
<tbody>
<tr>
<td>numbertubes</td>
<td>23</td>
</tr>
<tr>
<td>Prs</td>
<td>0.7229 [-]</td>
</tr>
<tr>
<td>(\rho)</td>
<td>1.173 [kg/m³]</td>
</tr>
<tr>
<td>St</td>
<td>0.01</td>
</tr>
<tr>
<td>V</td>
<td>1</td>
</tr>
</tbody>
</table>

1 potential unit problem was detected.
Purple units were automatically set. Right click on the variable to confirm or change the units.