Water flows with the velocity U_∞=0.2 m / s parallel to a plane wall. The following calculations refer to the position x = 6m measured downstream from the leading edge. The water properties can be evaluated at 20^0C.

(a) A probe is to be inserted in the viscous sublayer to the position represented by y^+=2.7.Calculate the actual spacing y (mm) between the probe and the wall.

(b) Calculate the boundary layer thickness δ, assuming that the length x is covered by turbulent boundary layer flow.

(c) Calculate the heat transfer coefficient averaged over the length x.

In[•]:=
```
U∞ = 0.2; L = 6;
ρ = ThermodynamicData["Water", "Density",
     {"Temperature" → Quantity[20, "DegreesCelsius"]}][[1]];
μ = ThermodynamicData["Water", "Viscosity",
     {"Temperature" → Quantity[20, "DegreesCelsius"]}][[1]];
κ = ThermodynamicData["Water", "Density",
     {"Temperature" → Quantity[20, "DegreesCelsius"]}][[1]];
Cp = ThermodynamicData["Water", "IsobaricHeatCapacity",
     {"Temperature" → Quantity[20, "DegreesCelsius"]}][[1]];
ν = μ/ρ; Pr = μ Cp/κ;
ReL = U∞ L/ν
```

Out[•]=
$$1.19594 \times 10^6$$

In[•]:=
```
Rex = U∞ x/ν;
Cf = 0.0624/Rex^(1/5);
uτ = U∞ Sqrt[(Cf/2)];
y+ = y uτ/ν;
Solve[(y+ == 2.7) /. x → L, y, Reals]
```

Out[•]=
$$\{\{y \to 0.000310813\}\}$$

In[•]:=
```
δ = 0.4013 x Rex^(-1/5) /. x → L
```

Out[•]=
$$0.146581$$

In[•]:=
```
Nux = Cf/2 Rex Pr^(1/3);
```

In[•]:=
```
NuMean = ∫_0^L Nux/x dx
```

Out[•]=
$$458.059$$

In[ ]:= $\text{hMean} = \text{NuMean}\,\frac{\kappa}{L}$

Out[ ]=

76 206.3