Challenge #1

No collaboration
Goal: Determine the temperature at the outlet of the tank with a non-uniform temperature imposed at the bottom of the tank using the *User Define Function* (UDF). For this example the settings and dimensions of Task 1 Case B will be used.

The desired un-uniform temperature for the bottom plate is described by the following equation:

$$T(r) = 65\exp(-r/D)$$

Where *r* is the radial distance from the center of the bottom of the plate and *D* is the diameter of the cylinder. The imposed temperature is axially symmetric and *T(r)* is in °C. Since we are dealing with a rectangular coordinate system and not a cylindrical one we need to alter the inputs, using simple trig this can be accomplished.

$$r^2 = x^2 + z^2 \rightarrow r = \sqrt{x^2 + z^2}$$

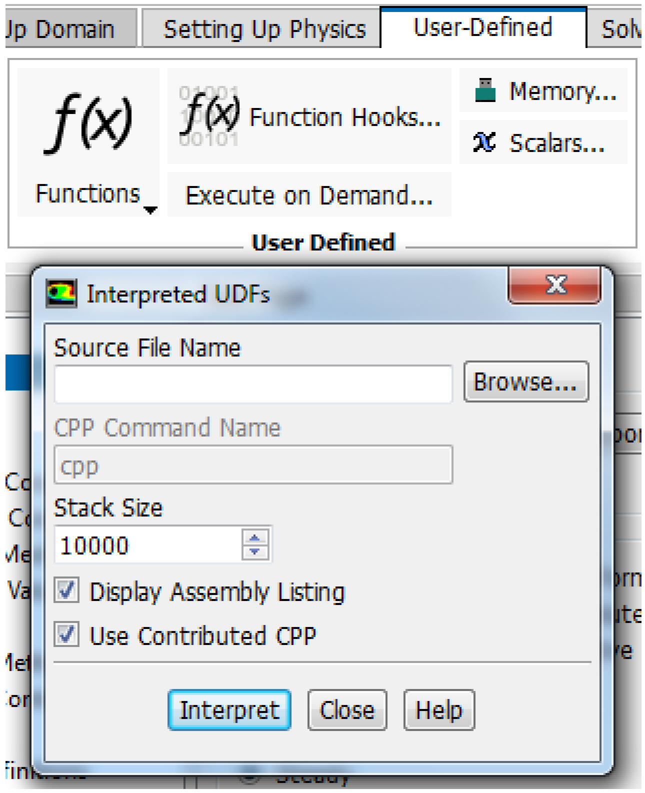
Now our equation can be written as such:

$$T(x,z) = 65\exp(-\sqrt{x^2 + z^2}/D)$$

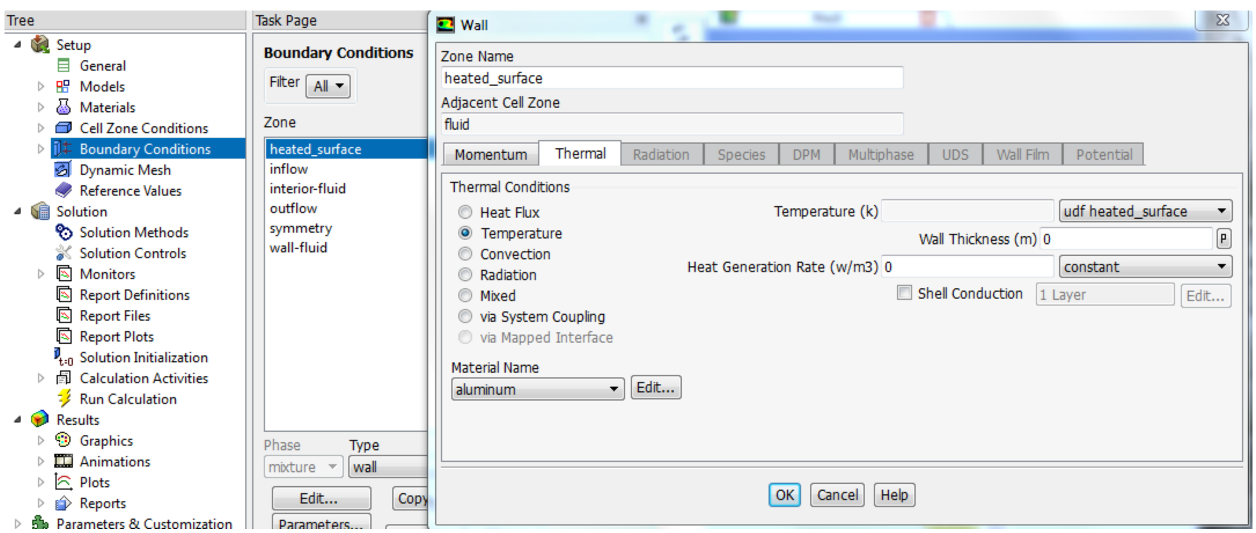
With the equation for the temperature at the bottom of the plate in rectangular coordinates a C code can be developed that creates the temperature gradient at the bottom of the plate based on the x and z coordinates. The following C code is as such:

```
#include "udf.h"


DEFINE_PROFILE(heated_surface, thread, position)
{
face_t f;
real y[ND_ND];
real x;
real z;

begin_f_loop(f, thread)
{
    F_CENTROID(y,f,thread);
    x = y[0];
    z = y[2];
    F_PROFILE(f, thread, position) = (65*exp(-sqrt(x*x+z*z)/0.5))+273.15;
}
end_f_loop(f, thread)
}
```

To insert the user defined C code into fluent you need to go to functions→Interpreted→Then browse for the desired C code and press Interpret. If no error arises the code is accepted.



Now the user defined function needs to be applied to the boundary, in this case the heated bottom plate. This is done by going to Boundary Conditions→Heated Surface Zone→Edit→then under the thermal settings change temperature from constant to the user defined function and click ok.



Now the Setup is completed and the calculations can be run to determine the average outlet temperature with a non uniform heated bottom.

Using the Custom Field Function Calculator and Surface Integrals in Reports:

```
                          Integral
                               num
-------------------------------- --------------------
                           outflow        0.0094692255

                          Integral
                               den
-------------------------------- --------------------
                           outflow       3.0911704e-05
```

$$T_{out} = \frac{\iint v_x T\, dA}{\iint v_x\, dA} = \frac{0.0094692255}{3.0911704 * 10^{-5}} = 306.33\ K = 33.18\ °C$$

As it can be observed this outlet temperature is smaller than the original Task 1 Case B outlet temperature. This is to be expected because the plates average temperature is less with the non-uniform temperature imposed.

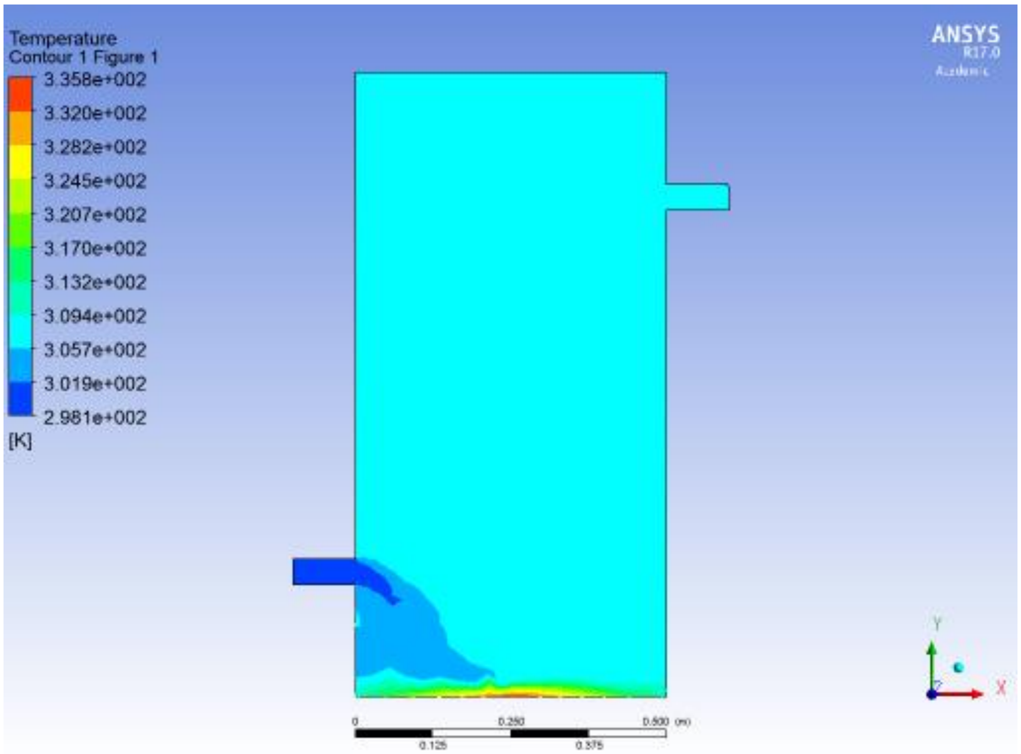


Figure 1. Temperature Contour of the water tank with the inlet and outlet pipes at $Y_1 = 0.2$ m and $Y_2 = 0.8$ m respectively with the non-uniform temperature imposed on the heating plate.

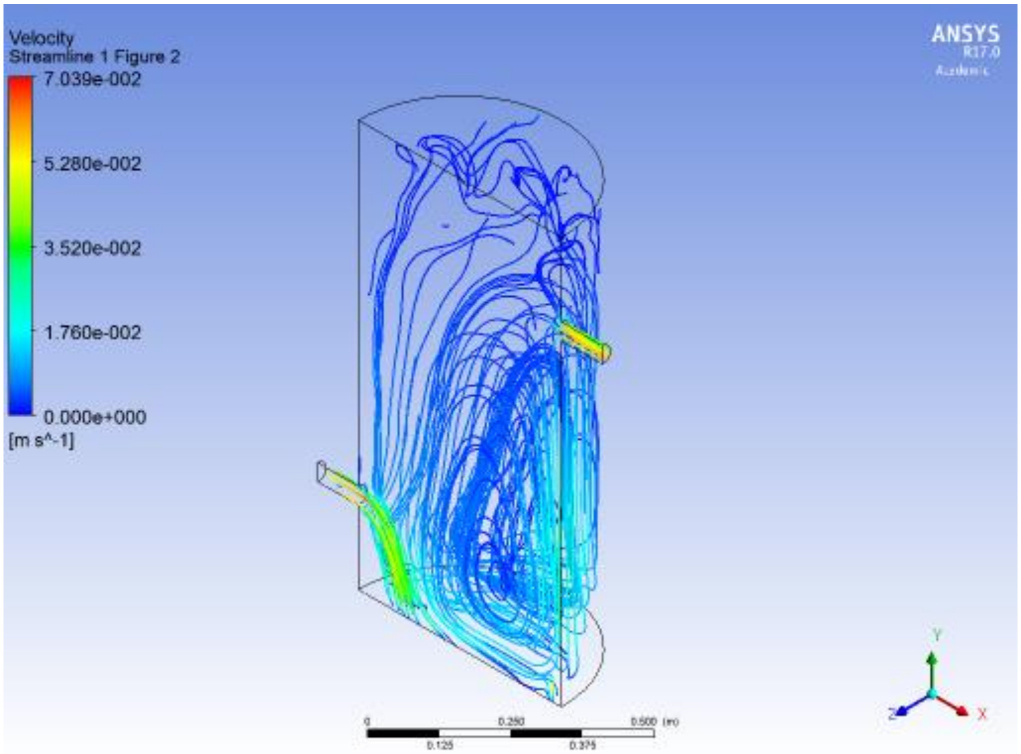


Figure 2. Velocity streamlines of the water tank with the inlet and outlet pipes at $Y_1 = 0.8$ m and $Y_2 = 0.2$ m respectively with the non-uniform temperature imposed on the heating plate.

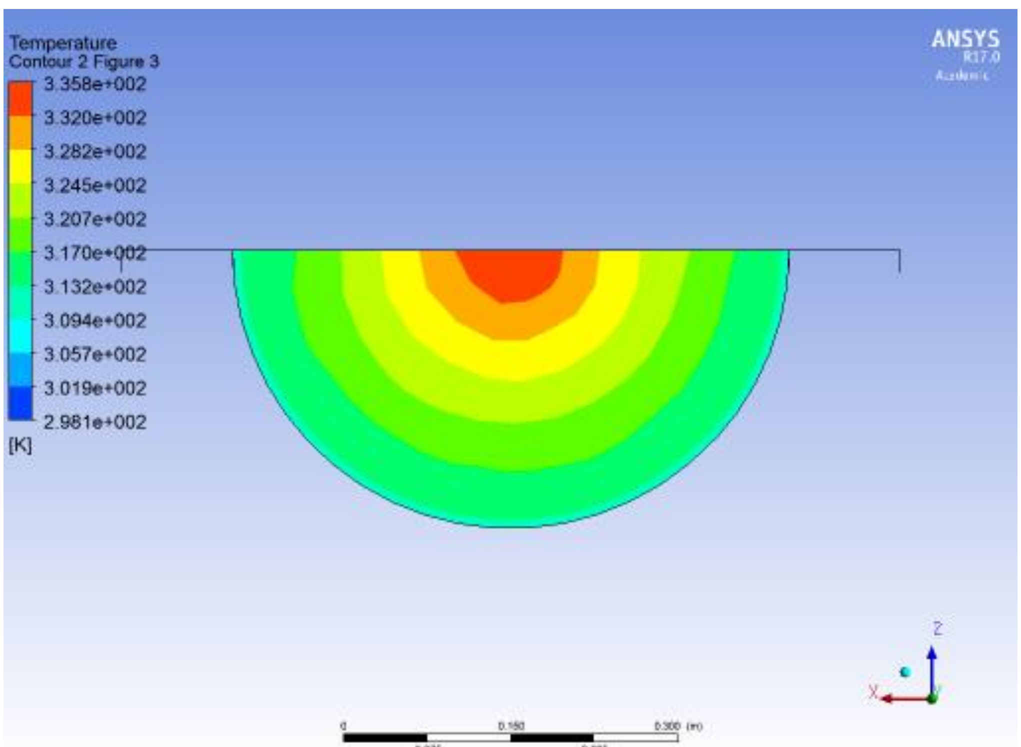


Figure 3. Temperature Contour of the water tanks heated bottom