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:

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

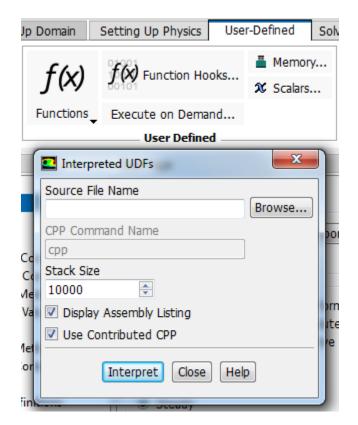
With the equation for the temperature at the bottom of the plate in rectangular coordinates a C code can be developed that creates the temperature gradient at the bottom of the plate based on the x and z coordinates. The following C code is as such:

```
#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 \rightarrow Interpreted \rightarrow Then browse for the desired C code and press Interpret. If no error arises the code is accepted.



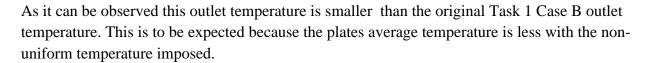
Now the user defined function needs to be applied to the boundary, in this case the heated bottom plate. This is done by going to Boundary Conditions \rightarrow Heated Surface Zone \rightarrow Edit \rightarrow then under the thermal settings change temperature from constant to the user defined function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

Tree	Task Page	🗹 Wall
■ Setup ■ General ■ B Models ■ Materials ■ Cell Zone Conditions ■ Cell Zone Conditions ■ Opnamic Mesh ● Reference Values ■ Solution ● Solution Controls ■ Monitors ■ Report Perintions ■ Report Plets • no Solution Activities • Calculation Activities • Run Calculation • Resourts	Boundary Conditions Filter Al Zone heated_surface inflow interior-fluid outflow symmetry wall-fluid	Zone Name heated_surface Adjacent Cell Zone fluid Momentum Thermal Radiation Species DPM Multiphase UDS Wall Film Potential Thermal Conditions Heat Flux Temperature (k) udf heated_surface • Temperature Wall Thickness (m) 0 P Convection Heat Generation Rate (w/m3) 0 constant • Radiation Heat Generation Rate (w/m3) 0 constant • Mixed Shell Conduction 1 Layer Edit via System Coupling via Mapped Interface Material Name aluminum • Edit
Graphics	Phase Type	
Animations	mixture 🔻 wall	
Plots		OK Cancel Help
Reports	Edit Copy	
Parameters & Customization	Parameters	

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

	Integral num
0.0094692255	outflow
	Integral den
3.0911704e-05	outflow
$= \frac{0.0094692255}{3.0911704 * 10^{-5}} = 306.33 K = 33.18 °C$	$T_{out} = \frac{\iint v_x T dA}{\iint v_x dA} =$

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



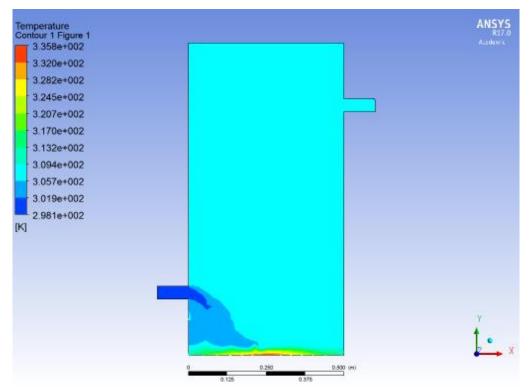


Figure 1. Temperature Contour of the water tank with the inlet and outlet pipes at $Y_1 = 0.2$ m and $Y_2 = 0.8$ m respectively with the non-uniform temperature imposed on the heating plate.

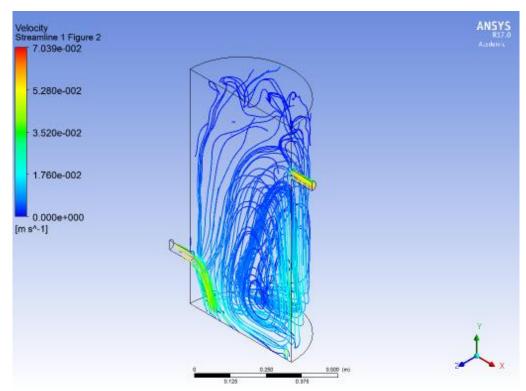


Figure 2. Velocity streamlines of the water tank with the inlet and outlet pipes at $Y_1 = 0.8$ m and $Y_2 = 0.2$ m respectively with the non-uniform temperature imposed on the heating plate.

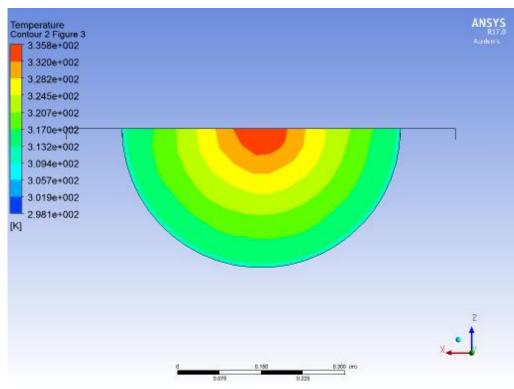


Figure 3. Temperature Contour of the water tanks heated bottom