Home Work Problem 8

This problem involves free convection flow at a heated vertical wall and the numerical solution of the simplified non-dimensionalized equations. Use the explicit method as discussed in class.
Solve for the dependent variables \(U_{\text{bar}}, V_{\text{bar}},\) and \(\theta\). Use the initial and boundary conditions are follows:

\(\tau = 0:\)
\(U_{\text{bar}} = V_{\text{bar}} = 0, \ \theta = 0.\)

\(\tau > 0:\)
\(\xi = 0: \quad U_{\text{bar}} = V_{\text{bar}} = 0, \ \theta = 0.\)
\(\eta = 0: \quad U_{\text{bar}} = V_{\text{bar}} = 0, \ \theta = 1.\)
\(\eta = \text{infinity}: \quad U_{\text{bar}} = 0, \ \theta = 0.\)

Use the following for dimensional calculations: \(T_w = 50 \, \text{C}, \) and \(T_{\infty} = 20 \, \text{C}.\)
Assume that the coefficient of thermal expansion is constant and is given by the following expression.

\[\beta = \frac{1}{\left(\frac{T_w + T_{\infty}}{2} + 273\right)} \quad \text{(1/K)}.\]

The time step must satisfy the approximate stability criterion given below.

\[\frac{\Delta \tau}{(\Delta \eta)^2} \leq \frac{1}{2}\]

For the finite domain for your calculation choose \(\xi_{\text{max}} = 100,\) and \(\eta_{\text{max}} = 25.\)
Use \(\Delta \xi = 10, \ \Delta \eta = 2.5\) and \(\Delta \tau = 0.5.\)

1. Prepare a detailed flow diagram of the calculations that you will be doing. Follow the example given in class.
2. Calculate the variables at \(\tau = 80.\) Show the result in tabular form as indicated in the figure given below. Plot the distributions of the dimensional velocities and temperature along a horizontal line where \(\xi = \xi_{\text{max}}/2.0.\)
3. Write a short note describing the procedure, details of the calculations and discussion of the results. Attach a listing of your computer program.
Make 3 tables for U, V, and theta values for the nodes. Choose print interval such that you show only 10 values in each direction at equally spaced nodes.