

Computational Fluid Dynamics (AE/ME 339)
MAEEM Dept.

Home Work Problem

Transform the simplified equations of free convection flow into non-dimensional form using the following non-dimensionalization scheme. Assume $\alpha = \nu$.

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$$
$$\frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} = g_x \beta (T - T_\infty) + \nu \frac{\partial^2 u}{\partial y^2}$$

where β is the coefficient of thermal expansion.

$$\beta = -\frac{1}{\rho} \frac{d\rho}{dT}$$

$$\frac{\partial T}{\partial t} + u \frac{\partial T}{\partial x} + v \frac{\partial T}{\partial y} = \alpha \frac{\partial^2 T}{\partial y^2}$$

$$\xi = x(g\beta\Delta T/\nu^2)^{\frac{1}{3}}$$
$$\eta = y(g\beta\Delta T/\nu^2)^{\frac{1}{3}}$$
$$\tau = t(g\beta\Delta T)^{\frac{2}{3}}/\nu^{\frac{1}{3}}$$
$$\bar{u} = u/(\nu g\beta\Delta T)^{\frac{1}{3}}$$
$$\bar{v} = v/(\nu g\beta\Delta T)^{\frac{1}{3}}$$
$$\theta = \frac{T - T_\infty}{T_1 - T_\infty} = \frac{T - T_\infty}{\Delta T}$$