APENDIX

The governing partial differential equations of our problem are:

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0 \tag{1}$$

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=\upsilon\frac{\partial^2 u}{\partial y^2}-\frac{\sigma_c B_o^2}{\rho_f}u-\frac{\upsilon}{k_o}u \tag{2}$$

$$u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}=\alpha\frac{\partial^2 T}{\partial y^2}+\tau\left\{D_b\frac{\partial c}{\partial y}\frac{\partial T}{\partial y}+D_t\left(\frac{\partial T}{\partial y}\right)^2\right\} \tag{3}$$

$$u\frac{\partial c}{\partial x}+v\frac{\partial c}{\partial y}=D_b\frac{\partial^2 c}{\partial y^2}+\frac{D_t}{T_f}\frac{\partial^2 T}{\partial y^2} \tag{4}$$

$$u\frac{\partial n}{\partial x}+v\frac{\partial n}{\partial y}+\frac{b_{ch}W_{cs}}{\left(c_w-c_f\right)}\left\{\frac{\partial}{\partial y}\left(n\frac{\partial c}{\partial y}\right)\right\}=D_m\frac{\partial^2 n}{\partial y^2} \tag{5}$$

To transform the above system of equations into Ordinary ones, we will utilize appropriate transformations given above in (8).

Since in terms of stream function, the velocity components have form:

$$u=\frac{\partial\psi}{\partial y},\ v=-\frac{\partial\psi}{\partial x}.$$

$$u=\frac{\partial\psi}{\partial y}=\left(\frac{a_o}{\nu}\right)^{\frac{1}{2}}x f'\left(a_o\nu\right)^{\frac{1}{2}}=a_o x f',\ v=-\frac{\partial\psi}{\partial x}=-\left(a_o\nu\right)^{\frac{1}{2}}f$$

By taking derivatives, we obtain:

$$\frac{\partial u}{\partial x}=a_o f'\Rightarrow\frac{\partial^2 u}{\partial x^2}=0,\ \frac{\partial u}{\partial y}=\left(\frac{a_o}{\nu}\right)^{1/2}a_o x f''\Rightarrow\frac{\partial^2 u}{\partial y^2}=\frac{a_o^2}{\nu}x f'''$$

And

$$\frac{\partial v}{\partial y}=-a_o f'$$

Now, by putting values of derivatives in Eq. (1), it is identically satisfied.

In the similar manner, Substitution of values of derivatives in Eq. (2) yields the form:

$$a_o x f'\left(a_o f'\right)+\left(-\left(a_o\nu\right)^{1/2}f\right)\frac{a_o^{3/2}}{\nu^{1/2}}x f''=$$

$$\nu\left(\frac{a_o^2}{\nu}x f'''\right)-\frac{\sigma_c B_o^2}{\rho_{fl}}a_o x f'-\frac{\nu}{k_o}a_o x f'$$

By simplifying above equation, we have obtained Eq. (9):

$$f'''+ff''-f'^2-M(f')-\gamma(f')=0$$

Similarly, by attaining derivatives and substituting their values, we have converted Eqs. (3)-(5) into Eqs. (10)- (12) respectively.