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Effect of Parabolic flow past started a vertical plate in the presence of rotating fluid with uniform temperature and variable mass diffusion in the absence of MHD

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ABSTRACT

Radiative effects on an unsteady free convective flow of a viscous incompressible flow of a past an uniform accelerated infinite isothermal vertical plate with variable temperature and mass dispersion in the absence of magnetic field are considered. The fluid considered here is a gray, absorbing- emitting radiation but a non -scattering medium. The plate temperature is raised to T_w and the concentration level near the plate is also raised to C'_w. A plate is uniformly accelerated with a velocity $u = u_o t'$ in its own plane against gravitational field. The effects of velocity, temperature and concentration fields are studied for different physical parameters such as the Schmidt value, thermal Grashof value, mass Grashof value and time.

Keywords: Heat and mass transfer, accelerated, vertical plate, parabolic, rotation.

1. Introduction

In fluid mechanics we as a sub discipline fluid dynamic which approaches with follow of the fluid. i.e., the motion of gases and liquids. We use the solution of the problems in fluid dynamics are involved in calculating the different properties of the fluid, such as density, temperature, pressure and velocity under the functions of time and space. Aerodynamics is one of some sub disciplines of fluid dynamics. (i.e., the investigation of air and different gases moving) also hydrodynamics (The investigation of fluids moving). It has broad scope of utilizations, along with manipulating movements and forces on airplane also determine the mass stream pace of petrol over channels, also find the nature of patterns in weather and also demonstrating blasts. Some principles of fluid dynamics are utilized in crowd and traffic engineering dynamics.

In material science and design, fluid elements are the branch of fluid mechanics that describes the evolution of fluids (liquids and gases). It has several sections, including optimal design (Studying the motion of air and various gases) and fluid mechanics (Studying the motion of liquids). Liquid cells have a wide range of applications, including storing power and minutes in aircraft, determining the mass flow rate of gasoline through pipelines, predicting climatic conditions, compassionate rebulars in the space between stars, also highlighting fusible weapons explosions.

Rudra Karta Deka, Ashish Paul discussed about transient free convection flow past an accelerated vertical cylinder in a rotating fluid. Velmurugan S studied about theoretical study of heat transfer effects on flow past a parabolic started vertical plate in the presence of chemical reaction of first order.Selvaraj A studied about rotating significance of parabolical movement antique with an appearance on isothermal vertical plate by MHD. Cramer.K.R studied about Magneto fluid dynamics for engineers and applied physics. Selvaraj A studied about Uniform mass diffusion on thermal radiation with rotation of parabolic in progress

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vertical plate set MHD. Visalakshi analyzed about radiative flow past an exponentially accelerated vertical plate with variable temperature and mass diffusion. Mansour M.H analyzed about radiative and free convection effects on the oscillatory flow past a vertical plate. Ramachandra Prasad V discussed about radiation and mass transfer effects on two-dimensional flow past an impulsively started infinite vertical plate

2. Related Work

R.C.Sharma analyzed about the thermal instability of compressible fluids pervaded by a uniform rotation and a uniform magnetic field, separately, is considered. For $(Cp/g)\beta < 1$, with Cp, g and β denoting the specific heat at constant pressure, the acceleration due to gravity, and the uniform temperature gradient, respectively, the system is shown to be stable. The magnetic field as well as rotation introduces oscillatory modes in thermal instability of compressible fluids, which are completely missing for $(Cp/g)\beta > 1$ in th absence of rotation or magnetic field.

Rudra Kanta Deka studied about the flow of a viscous incompressible fluid past an accelerated vertical circular cylinder in a rotating fluid is analyzed in this study. The cylinder starts impulsively form rest with uniform acceleration in its own plane relative to the rotating fluid. The closed form solutions of the governing boundary layer equations in nn-dimensional form are obtained in terms of Bessel functions and modified Bessel functions by Laplace transform technique.

Ramachandra Prasad discussed about the interaction of free convection with thermal radiation of a viscous incompressible unsteady flow past an impulsively started vertical plate with heat and mass transfer is analyzed. The fluid is gray, absorbing-emitting but non-scattering medium and the Rosseland approximation is used to describe the radiative flux in the energy equation. The dimensionless governing equations are solved using an implicit finite-difference method of Crank-Nicolson type.

3. Analysis

Consider an unstable hydromagnetic flow in an electrically conducting fluid generated by viscous gluey incompressible fluid past an uniformly accelerated vertical plate of an never ending vertical plate with temperature T_∞ and concentration C'_∞ is studied. The x-axis is taken along the plate in the vertically upward direction and the y-axis is taken normal to the plate. Initially, it is assumed that the plate and the fluid are of the same temperature and concentration. At time $t' > 0$, the plate is uniformly accelerated with a velocity $u = u_0 t'$in its own plane and the temperature from the plate is raised to T_w and the concentration level near the plate is also raised to C'_w . The plate is also subjected to a uniform magnetic field of strength B_0 assumed to be applied normal to the plate. The fluid considered here is a gray, absorbing-emitting radiation but a non-scattering medium. It is assumed that the effect of viscous dissipation is negligible in the energy equation. Then by usual Boussinesq's approximation, the unsteady flow is governed by the following equations.

$$\frac{\partial u}{\partial t'} - 2\Omega' V' = g\beta(T - T_\infty) + g\beta^*(C' - C'_\infty) + v\frac{\partial^2 u}{\partial z^2} - \frac{\sigma B_0^2}{\rho}u \tag{1}$$

$$\frac{\partial V'}{\partial t'} + 2\Omega' u = \frac{\partial^2 V'}{\partial z^2} - \frac{\sigma B_0^2}{\rho}V' \tag{2}$$

$$\rho C_p \frac{\partial T}{\partial t'} = k\frac{\partial^2 T}{\partial z^2} \tag{3}$$

$$\rho C_p \frac{\partial C'}{\partial t'} = D\frac{\partial^2 C'}{\partial z^2} \tag{4}$$

With the pursuing introductory and ending condition:

$$\begin{gathered} u = 0,\ T = T_\infty,\ C' = C'_\infty \quad \textit{for all}\ \ y, t' \le 0 \\ t' > 0 \colon u = u_0 t',\ \ T = T'_\infty + (T'_w - T'_\infty),\ \ C' = C'_\infty + (C'_w - C'_\infty)\ \ \textit{at}\ \ y{=}0 \\ u \to 0, T \to T_\infty,\ C' \to C'_\infty\ \ \textit{as}\ \ y \to \infty \end{gathered} \tag{5}$$

On proposing the next non-dimensional quantities:

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$$U = \frac{u}{(vu_0)^{1/3}},\ V = \frac{V'}{(vu_0)^{1/3}}\ , t = t'\left(\frac{u_0^2}{v}\right)^{1/3}, Z = z\left(\frac{u_0}{v}\right)^{1/3},$$
$$\theta = \frac{T - T_\infty}{T_w - T_\infty}, Gr = \frac{g\beta(T_w - T_\infty)}{u_0}, C = \frac{C' - C'_\infty}{C'_w - C'_\infty}, Gc = \frac{g\beta^*(C'_w - C'_\infty)}{u_0} \qquad (6)$$
$$M = \frac{\sigma B_0^2}{\rho}\left(\frac{v}{u_0^2}\right)^{1/3}, \quad Pr = \frac{\mu C_p}{k}, \quad Sc = \frac{v}{D}, \quad A = \left(\frac{u_0^2}{v}\right)^{1/3}$$

We arrive at

$$\frac{\partial \mathrm{U}}{\partial \mathrm{t}} - 2\Omega \mathrm{V} = \mathrm{Gr}\theta + \mathrm{GcC} + \frac{\partial^2 \mathrm{U}}{\partial \mathrm{Z}^2} - \mathrm{MU} \qquad (7)$$
$$\frac{\partial \mathrm{V}}{\partial \mathrm{t}} - 2\Omega \mathrm{V} = \frac{\partial^2 \mathrm{V}}{\partial \mathrm{Z}^2} - \mathrm{MV} \qquad (8)$$
$$\frac{\partial \theta}{\partial \mathrm{t}} = \frac{1}{\mathrm{Pr}}\frac{\partial^2 \theta}{\partial \mathrm{Z}^2} \qquad (9)$$
$$\frac{\partial \mathrm{C}}{\partial \mathrm{t}} = \frac{1}{\mathrm{Sc}}\frac{\partial^2 \mathrm{C}}{\partial \mathrm{Z}^2} \qquad (10)$$

The initial and boundary conditions are

$$q = 0, \theta = 0, c = 0 \ for\ all\ z, t \le 0$$
$$q = t^2, \theta = 1, c = t \quad at \quad z = 0$$
$$q \to 0, \theta \to 0, c \to 0 \quad as \quad z \to \infty \qquad (11)$$

The magneto hydrodynamic spinning free convective stream past an increased upright plate is evaluated by paired differential condition (7) to (10) along recommended condition (11). To deal with (7) to (10) we suggest a velocity$q = U + iV$, equation seven and eight are joined into a lone condition

$$\frac{\partial q}{\partial t} = G_r\theta + G_c C + \frac{\partial^2 q}{\partial z^2} - mq \qquad (12)$$

Where $m = 2i\Omega$

$$
\begin{aligned}
q = 2\Bigg\{ & \frac{(\eta^2 + 2i\Omega t)}{4(2i\Omega)} t\left[e^{2\eta\sqrt{2i\Omega t}} erfc\left(\eta + \sqrt{2i\Omega t}\right) + e^{-2\eta\sqrt{2i\Omega t}} erfc\left(\eta - \sqrt{2i\Omega t}\right)\right] \\
& + \frac{\eta\sqrt{t}(1 - 4(2t)}{8(2i\Omega)^{3/2}}\Bigg[e^{-2\eta\sqrt{2i\Omega t}} erfc\left(\eta - \sqrt{2i\Omega t}\right) - e^{2\eta\sqrt{2i\Omega t}} erfc\left(\eta + \sqrt{2i\Omega t}\right) \\
& - \frac{\eta t}{2(2i\Omega)\sqrt{\pi}} e^{-(\eta^2 + 2i\Omega t)}\Bigg]\Bigg\} \\
& + \left[\frac{Gr}{a(1 - pr)} + \frac{Gc}{b^2(1 - sc)}\right]\left(\frac{1}{2}\right)\left[e^{2\eta\sqrt{2i\Omega t}} erfc\left(\eta + \sqrt{2i\Omega t}\right) + e^{-2\eta\sqrt{2i\Omega t}} erfc\left(\eta - \sqrt{2i\Omega t}\right)\right] \\
& + \frac{Gc}{b(1 - sc)}\Bigg[\left(\frac{t}{2} - \frac{c}{2\sqrt{2i\Omega}}\right)\left(e^{-2\eta\sqrt{2i\Omega t}} erfc\left(\eta - \sqrt{2i\Omega t}\right)\right) \\
& + \left(\frac{t}{2} + \frac{c}{2\sqrt{2i\Omega}}\right)\left(e^{2\eta\sqrt{2i\Omega t}} erfc\left(\eta + \sqrt{2i\Omega t}\right)\right)\Bigg] \\
& - \frac{Gr}{a(1 - pr)}\left(\frac{e^{at}}{2}\right)\Bigg[(e^{2\eta\sqrt{(2i\Omega + a)t}} erfc\left(\eta + \sqrt{(2i\Omega + a)t}\right) \\
& + e^{-2\eta\sqrt{(2i\Omega + a)t}} erfc\left(\eta - \sqrt{(2i\Omega + a)t}\right)\Bigg] \\
& - \frac{Gc}{b^2(1 - Sc)}\left(\frac{e^{bt}}{2}\right)\Bigg[(e^{2\eta\sqrt{(2i\Omega + b)t}} erfc\left(\eta + \sqrt{(2i\Omega + b)t}\right) \\
& + e^{-2\eta\sqrt{(2i\Omega + b)t}} erfc\left(\eta - \sqrt{(2i\Omega + b)t}\right)\Bigg] - \frac{Gr}{a(1 - pr)} erfc(\eta\sqrt{Pr}) \\
& - \frac{Gc}{b^2(1 - Sc)} erfc\ (\eta\sqrt{Sc}) \\
& + \frac{Gr}{a(1 - pr)}\left(\frac{e^{at}}{2}\right)\left[(e^{2\eta\sqrt{Prat}} erfc\left(\eta\sqrt{Pr} + \sqrt{at}\right) + e^{-2\eta\sqrt{Prat}} erfc\left(\eta\sqrt{Pr} - \sqrt{at}\right)\right] \\
& + \frac{Gc}{b^2(1 - Sc)}\left(\frac{e^{bt}}{2}\right)\left[(e^{2\eta\sqrt{Scbt}} erfc\left(\eta\sqrt{Sc} + \sqrt{bt}\right) + e^{-2\eta\sqrt{Scbt}} erfc\left(\eta\sqrt{Sc} - \sqrt{bt}\right)\right] \\
& - \frac{Gc}{b(1 - Sc)} t\Bigg[(1 + 2\eta^2 Sc) erfc\left(\eta\sqrt{Sc}\right) \\
& - \frac{2\eta\sqrt{Sc}}{\sqrt{\pi}} e^{-\eta^2 Sc}\Bigg] \qquad (13)
\end{aligned}
$$

$$\theta = erfc\left(\eta\sqrt{Pr}\right) \qquad (14)$$

$$C = t\left\{(1 + 2\eta^2 Sc) erfc\left(\eta\sqrt{Sc}\right) - \frac{2\eta\sqrt{Sc}}{\sqrt{\pi}} e^{-(\eta^2 Sc)}\right\} \qquad (15)$$

Where $\eta = \frac{Z}{2\sqrt{t}}$, $a = \frac{2i\Omega}{pr-1}$, $b = \frac{2i\Omega}{Sc-1}$,

$$erfc(a + ib) = \mathrm{erf}(a) + \frac{\exp(-a^2)}{2a\pi}[1 - \cos(2ab) + i\sin(2ab)] + \frac{2\exp(-a^2)}{\pi}\sum_{n=1}^{\infty}\frac{\exp(-\eta^2/4)}{\eta^2 + 4a^2}[f_n(a, b) + ig_n(a, b)] + \in(a, b)$$

4. Result and Discussion

For a physical understanding of the problem numerical computations are carried out for different physical parameters Gr, Gc, Sc and t. the value of the Schmidt number Sc is taken to be 0.6 which corresponds to water-vapor. Also, the values of the pradtl number Pr are chosen such that they represent air (Pr=0.71). The numerical values of the velocity are computed for different

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physical parameters such as the chemical reaction parameter, prandtl number, thermal Grashof number, mass Grashof number, Schmidt number and time.

Figure 1 presents the effect of primary velocity profile for various warm grashof values. It shows that the speed increases with extending assessments of the warm Grashof value (or) mass Grashof value. As the outcome is contrasted with past solution the translation proclaims to remains same in the record to the combination is researched here.

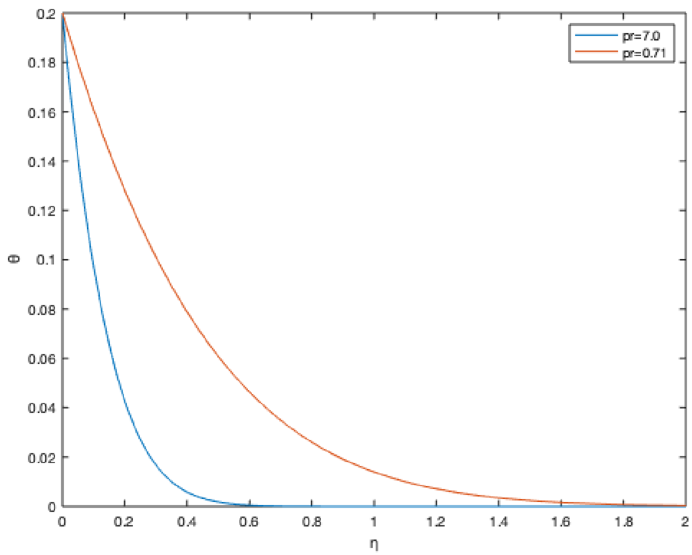

Figure 1. Temperature profiles to various Prandtl number

Figure 2 shows that the effects of alluring field limit on the speed. It is seen that the speed increase with decreasing assessments of the alluring field limit. This shows that the development in the alluring field limit prompts a fall in the speed.

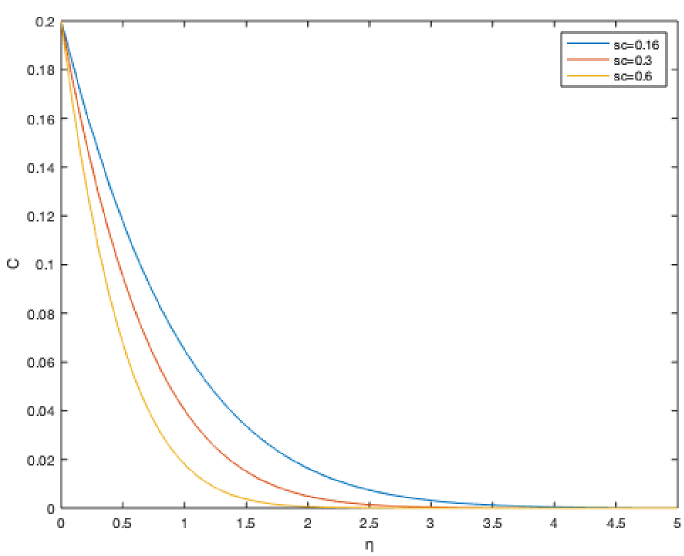

Figure 2. Concentration Profiles to various Schmidt number

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Figure 3 establishes the effect on the various thermal and mass grashof values Gr=2,5,10 and Gc=5,5,10. We consider the value of rotation parameter is 0.5, the prandtl value is 7 at initial velocity for the time value is 0.2. It also noticed that the value of velocity increase by increase in the value of thermal and mass grashof values Gr and Gc.

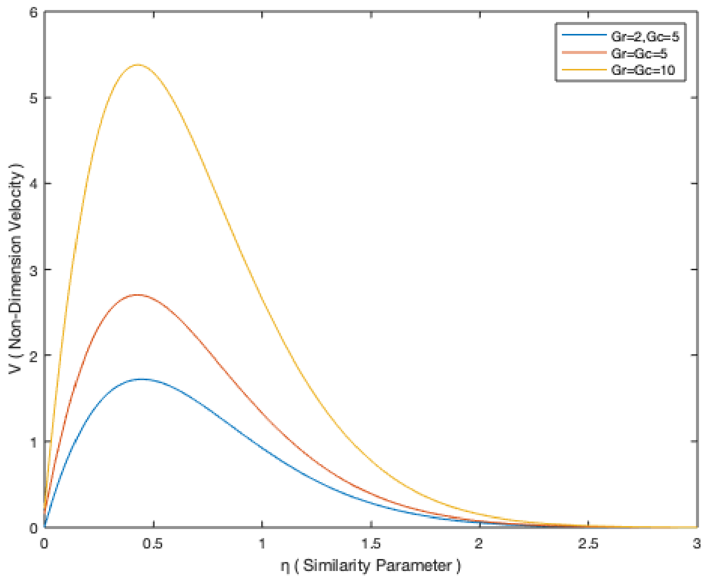

Figure 3. primary velocity profiles for various Gr and Gc

Figure 4 represents the effect on various rotation parameter values such as $\Omega = 0.5,1,1.5$ with the value of (Pr) Prandtl value as 7 with the Gr=Gc=5 and the value of time t=0.1. From this the velocity increases by decrease in the value of Ω.

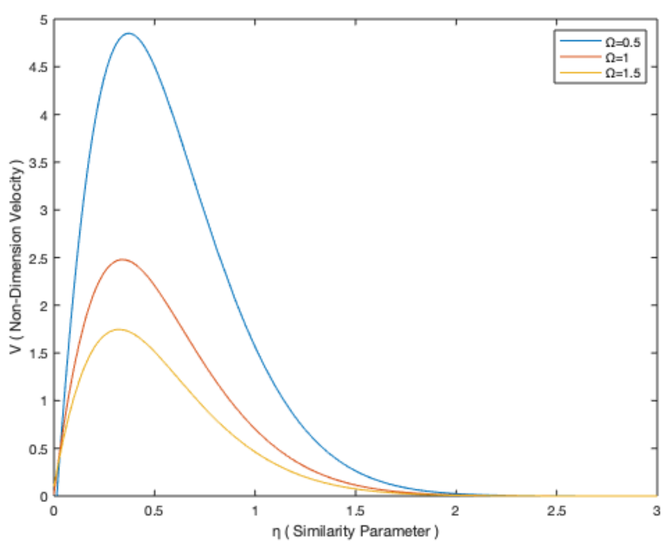

Figure 4. primary velocity profiles for various rotation parameter

Figure 5 represents the secondary velocity profile for various thermal and mass grashof value Gr=Gc=5, Gr=5;Gc=10 and Gr=Gc=10. Here we consider the rotation parameter as 0.5 an the prandtl value is 7. It shows that the value of velocity increase by increase in the values of Gr and Gc.

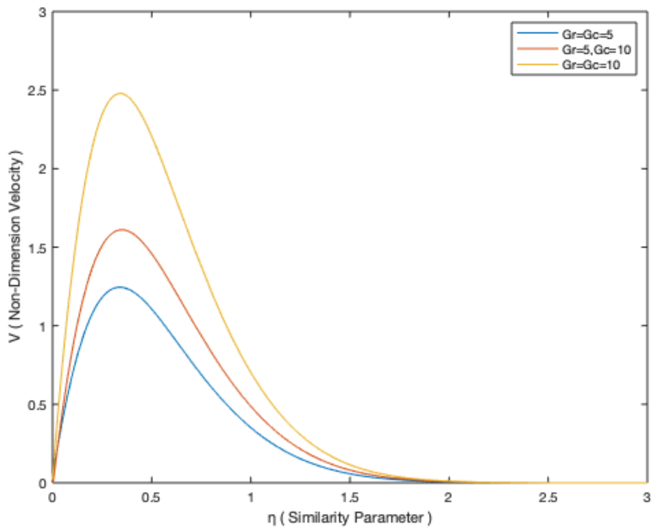

Figure 5. Secondary velocity profile for various Gr and Gc

Figure 6 represents the effect on secondary velocity profile for various value of rotation parameter by using various thermal and mass grashof values. With Gr=Gc=5 when $\Omega = 1$, Gr=5; Gc=10 when $\Omega = 1.5$ and for $Gr = Gc = 10$ when $\Omega = 2$. With the value of time t=0.2. This shows that the velocity increase by increase in the value of Ω.

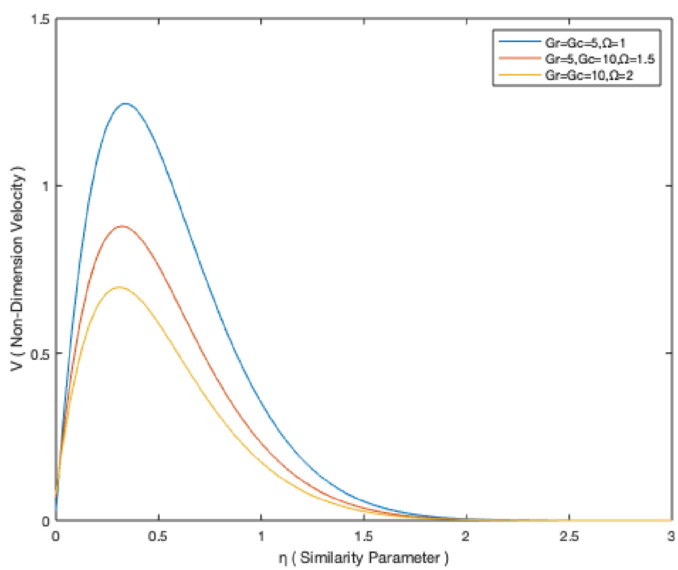

Figure 6. Secondary velocity profile for various Gr, Gc and for various rotation parameter

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5. Conclusion

It was conceived to move allegorical flow past a reliably revived large isothermal Perpendicular plate inward while variable mass distribution in a setting of uniform temperature. The Laplace transform approach is used to solve the dimensionless regulating condition. The Grashof value, the mass Grashof value, the rotational border, Prandtl value, Schmidt value, and time t are all investigated visually. We now know what happened.

- If Prandtl decreases, temperature rises.
- A drop in Schmidt value leads to an increase in concentrations.
- The faster increase in primary and secondary profiles for mass and thermal Grashof value assessments leads to an increase in velocity.
- As speed increases, the primary and secondary profiles for the Rotational parameter diminish.

Rapidity is clearly evident when assessments of warm or mass Grashof value are created. By switching the event, the spinning border is properly acknowledged.

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