Magneto Hydrodynamic Effects on Unsteady Free Convection Casson Fluid Flow Past on Parabolic Accelerated Vertical Plate with Thermal Diffusion

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Abstract

The free convection MHD flow of a viscous, chemically reactive, electrically conducted, incompressible, and Casson fluid past a parabolically accelerated vertical plate was examined in the present article along with the transfer of the heat & mass in the incidence of thermal radiation. The inverse Laplace method is used to resolve the dimensionless equations. The concentration and temperature fields, axial and transverse velocity are examined for distinct parameters like the \( \lambda \) (Casson fluid), \( Sc \) (Schmidt number), \( Gr \) (thermal Grashof number), \( Pr \) (Prandtl number), and \( Gm \) (mass Grashof number). Utilizing the temperature of fluid and concentration of species as a solution is also proposed. Graphical representations of the fluctuations in temperature of fluid and velocity along species concentration are provided for several values of relevant flow parameters.

1. Introduction

Many flow features within Newtonian fluid model are not understood. Consequently, it is beneficial to examine the non-Newtonian fluid model. Shear strain and shear stress rate have nonlinear connections under the influence of non-Newtonian fluid. It has various uses in engineering and industry, particularly when it comes to crude oil extraction from petroleum-based products. The crucial non-fluid model is the Casson fluid. It has many uses in food preparation, drilling operations, and bio-engineering processes. The review of non-Newtonian fluid flow in the parabolically conducting, viscous, incompressible, as well as heat-absorbing fluid flow through an accelerating plate. Jose et al., [16] determined the convective mass and heat transfer impacts of rotation on parabolic flow through an accelerated iso-thermal vertical plate during a first-order chemical process. Selvaraj et al., [1] examined MHD-parabolic flow over an accelerated mass and heat diffusion and isothermal vertical plate during rotation. Lakshmikaanth et al., [3] determined the heat and Hall


with thermal diffusion along with chemical reaction impacts on above mentioned MHD convection with exponentially accelerated inclined plate. Siddiqa et al., [20] research on the heat transfer over a vertically wavy cone with a radiating surface including a fluid flow of Casson dusty. The effects of radiation on a parabolic flow moving along an infinite and isothermal vertical plate while an exponentially accelerating via porous medium by Selvaraj et al., [22,23]. Usharani et al., [24] researched impact of MHD exponentially accelerated inclined vertical plate with 1st order chemical reaction. Goud [25] study examines the effects of heat generation or absorption on the continuous MHD flow of a stretched, semi-infinite vertical plate through porous media with varying suction/injection and magnetic field participation.

Goud et al., [26] examined the heat source influence on an unsteady MHD Casson fluid flow over a vertical oscillating plate in a porous material is solved numerically in this article. Goud, B. Shankar et al., [27] find out the effect of the Dufour number, as well as viscous dissipation, on the non-steady flow of heat, as well as the mass transfer of Casson fluid, on vertical permeable laminate is explored using chemical reaction. Goud, B. Shankar et al., [28] inspected the influence of the Eckert number and the Prandtl number on a magnetohydrodynamic natural convection flow of an incompressible viscous electrically conducting fluid flowing through a perpendicular microchannel is determined numerically. Analysis is done on conduction and non-conducting, immeasurable, perpendicular walls at the microchannel when temperature and velocity slip are present. Rebhi et al., [29] study about the current research is primarily concerned with assessing thermal performance in solar receivers and heat exchangers that use forced thermal transfer. Alkasasbeh et al., [30] using an Al2O3+CuO/SA Williamson hybrid nanofluid, investigate the properties of heat and mass transfer flow through a
stretched sheet in conjunction with a magnetic field and thermal radiation. Armstrong, A. Neel et al., [31] the effects of medium rotation and porosity on the unsteady convection flow of a viscous, incompressible, and electrically conducting flow across a starting vertical plate under the impact of transversely applied uniform mass diffusion are investigated. Ilyas Khan et al., [32] investigated the use of fractional derivatives to characterize and study blood flow behavior as well as the processes of blood flow over an inclined surface or structure when nanofluids are present. Makinde et al., [34] examined the unstable mixed convection flow through a vertical porous plate traveling through a binary mixture in the presence of radiative heat transfer. Soundalgekar et al., [10,33] the effects of mass and free exchange on the MHD Stokes (Rayleigh) problem of electric, incompressible, viscous fluids flowing through an incompressible initial vertical plate in conjunction with the workplace connection have been carefully studied.

The purpose of this article is to explore the development of an uncoupled, unstable model for vertical plate MHD. Casson fluid with thermal diffusion effects. A new feature of thermal explosive mass propagation has been discovered. The subject revolves around the nonlinear electric current of dimensionless magnetohydrodynamic flow of Carson fluid in a vertical plate, with a focus on mass propagation, which has received little attention previously. The Laplace transform method is used to solve differential equations with beginning and boundary conditions as well as control parameters. Convergence of the solution is critical since the nature of the problem is the output of the solution. This discovery could have applications in solar energy harvesting systems, recycling petroleum products, and fire-resistant insulating materials.

2. Mathematical Analysis

Figure 1 shows geometry of present model the coordinate system was designed to take into account the Casson fluid model’s unsteady motion with electrically conducting fluid moving via a vertical plate with the, $x^*$ axis along the plate in an upward direction, $y^*$-axis normal to the plate, as well as $z^*$-axis vertical to the, $x^*y^*$-plane. The fluid is permitted by the same transverse magnetic field $B_0$, this is employed diagonally to the $y^*$-axis. We assume that at the time $\bar{t} \leq 0$, both plate as well as fluid are at rest and kept at an even surface concentration $\bar{C}_\infty$ and uniform temperature $\bar{T}_\infty$.

At time $\bar{t} \geq 0$, the plate starts to move in $x^*$-direction against gravitational field along with time dependent velocity $\bar{u}$. Plate temperature is decreased or increased to $\bar{T}_\infty + (\bar{T}_w - \bar{T}_\infty) \frac{u_0 \bar{t}^{2/3}}{v}$ at $\bar{t} \geq 0$ and plate concentration is raised or lowered to $\bar{C}_\infty + (\bar{C}_w - \bar{C}_\infty) \frac{u_0 \bar{t}^{2/3}}{v}$ at $\bar{t} \geq 0$. The rheological state equation for Cauchy stress tensor of Casson fluid is presented below

$$\tau_{ij} = \begin{cases} 
2\varepsilon_{ij} \left( \mu_B + \frac{py}{\sqrt{2\pi}} \right) & \pi > \pi_c \\
2\varepsilon_{ij} \left( \mu_B + \frac{py}{\sqrt{2\pi c}} \right) & \pi < \pi_c 
\end{cases}$$

(1)
With the aforementioned conditions, we obtain the following equation for concentration, temperature, and velocity. Initial boundary conditions are provided below.

\[
\frac{\partial \bar{u}}{\partial \bar{t}} = \frac{\mu_B}{\rho} \left( \frac{1}{1+\lambda} \right) \frac{\partial^2 \bar{u}}{\partial \bar{y}^2} - \frac{\mu_B}{\rho k_1} \frac{\sigma B_o \bar{u}}{\rho} + g \beta (\bar{T} - \bar{T}_\infty) + g \beta_c (\bar{C} - \bar{C}_\infty) \quad (2)
\]

\[
\frac{\partial \bar{T}}{\partial \bar{t}} = \frac{k}{\rho c_p} \frac{\partial^2 \bar{T}}{\partial \bar{y}^2} - \frac{1}{\rho c_p} \frac{\partial q_r}{\partial \bar{y}} \quad (3)
\]

\[
\frac{\partial \bar{C}}{\partial \bar{t}} = D \frac{\partial^2 \bar{C}}{\partial \bar{y}^2} \quad (4)
\]

Boundary conditions for flows are expressed as

\[
\bar{u} = 0, \bar{T} = \bar{T}_\infty, \bar{C} = \bar{C}_\infty \quad \text{for} \quad \bar{t} \leq 0; \bar{y} \geq 0
\]

\[
\bar{u} = \frac{u_0 \bar{t}}{v}, \quad \text{at} \quad \bar{y} = 0 \quad \text{for} \quad \bar{t} \geq 0
\]

\[
\bar{T} = \bar{T}_\infty + (\bar{T}_w - \bar{T}_\infty) \frac{u_0 \bar{t}}{v}, \quad \text{at} \quad \bar{y} = 0 \quad \text{for} \quad \bar{t} > 0
\]

\[
\bar{C} = \bar{C}_\infty + (\bar{C}_w - \bar{C}_\infty) \frac{u_0 \bar{t}}{v}, \quad \text{at} \quad \bar{y} = 0 \quad \text{for} \quad \bar{t} > 0
\]

\[
\bar{u} \to 0, \bar{T} \to \bar{T}_\infty, \bar{C} \to \bar{C}_\infty \quad \text{at} \quad \bar{y} \to \infty \quad \text{for} \quad \bar{t} > 0
\]

The local gradient for optically slim gas can be written as

\[
\frac{\partial q_r}{\partial \bar{y}} = -4a \sigma (\bar{T}_\infty^4 - \bar{T}^4) \quad (6)
\]
Temperature modifications within flow are appropriately small and that $\bar{T}^4$ maybe denoted as a temperature’s linear function. To attained $\bar{T}^4$ solving Taylor series about $\bar{T}_\infty$ and overlooking the terms that are higher in order, we attain

$$\bar{T}^4 = 4\bar{T}_\infty^3 \bar{T} - 3\bar{T}_\infty^4$$  \(7\)

Substituting Eq. (6) and (7) in (3), we get

$$\frac{\partial \bar{T}}{\partial t} = \frac{k}{\rho c_p} \frac{\partial^2 \bar{T}}{\partial t^2} - \frac{16\bar{a}\sigma}{\rho c_p} \bar{T}_\infty^3 (\bar{T} - \bar{T}_\infty)$$  \(8\)

The following definitions apply to the dimensionless parameters and variables.

$$y = \frac{\bar{y}u_0}{v}, u = \frac{\bar{u}}{u_0}, t = \frac{\bar{t}u_0^2}{v}, T = \frac{\bar{T} - \bar{T}_\infty}{\bar{T}_w - \bar{T}_\infty}, C = \frac{\bar{C} - \bar{C}_\infty}{\bar{C}_w - \bar{C}_\infty}, \mu = \rho v, k_1 = \frac{u_0^2k_1}{v^2}, P_r = \frac{\mu c_p}{k}$$

$$S_c = \frac{v}{D}, G_r = \frac{g \beta_T v(\bar{T}_w - \bar{T}_\infty)}{u_0^3}, G_m = \frac{g \beta_C v(\bar{C}_w - \bar{C}_\infty)}{u_0^3}, M = \frac{\sigma b_0^2 v}{\rho u_0^2}, R = \frac{16\bar{a}\sigma v^2 \bar{T}_\infty^3}{k u_0^2}, k = \frac{v k}{u_0^2}$$  \(9\)

We have the dimensionless version of the following governing equation.

$$\frac{\partial U}{\partial t} = (1 + \lambda) \frac{\partial^2 U}{\partial y^2} - \frac{(Mk_1 + 1)}{k_1} U + G_r T + G_m C$$  \(10\)

$$\frac{\partial T}{\partial t} = \frac{1}{P_r} \frac{\partial^2 T}{\partial y^2} - \frac{R}{P_r} T$$  \(11\)

$$\frac{\partial^2 C}{\partial y^2} = \frac{1}{S_c} \frac{\partial^2 C}{\partial y^2}$$  \(12\)

and corresponding boundary conditions become

$$U = 0, T = 0, C = 0 \quad \text{for } y \geq 0 \text{ & } t \leq 0$$

$$U = t^2, T = t, C = t \quad \text{at } y = 0 \text{ for } t > 0$$

$$T \to 0, U \to 0, C \to 0, \text{ as } y \to \infty \text{ for } t > 0$$  \(13\)

The above-mentioned eq. could be expressed in the following form

$$\frac{\partial U}{\partial t} = m \frac{\partial^2 U}{\partial y^2} - nU + G_r T + G_m C$$  \(14\)

$$\frac{\partial T}{\partial t} = \frac{1}{P_r} \frac{\partial^2 T}{\partial y^2} - \frac{R}{P_r} T$$  \(15\)

$$\frac{\partial C}{\partial t} = \frac{1}{S_c} \frac{\partial^2 C}{\partial y^2}$$  \(16\)
3. The Method of Solution

The dimensionless governing equations from (14)-(16) according to boundary conditions (13) may be resolved with the Laplace transform approach to attain the precise solution for fluid concentration, velocity, and temperature, which is then found in the following method is used to get the solutions with help of Hetnarski [18] find out the inverse Laplace transform algorithm.

The fluid concentration can be represented as

\[ C = \left( t + \frac{y^2 S_c}{2} \right) \text{erfc} \left( \frac{y \sqrt{S_c}}{2 \sqrt{t}} \right) - \frac{y \sqrt{S_c}}{2 \sqrt{\pi}} \exp \left( -\frac{y^2 S_c}{4t} \right) \]  \hspace{1cm} (17)

The fluid temperature can be expressed as

\[ T = \left( \frac{t}{2} - \frac{P_r y}{4R} \right) \exp \left( -y \sqrt{R} \right) \text{erfc} \left( \frac{y P_r}{2 \sqrt{t} \sqrt{R}} - \sqrt{\frac{R}{P_r}} t \right) \]

\[ + \left( \frac{t}{2} + \frac{P_r y}{4R} \right) \exp \left( y \sqrt{R} \right) \text{erfc} \left( \sqrt{\frac{R}{P_r}} t + \frac{y P_r}{2 \sqrt{t} \sqrt{R}} \right) \]  \hspace{1cm} (18)

The fluid velocity could be expressed using the following formula:

\[ U = \left( \frac{y^2}{8 \beta m n} + \frac{t^2}{2} \right) \left[ \exp \left( -\frac{y \sqrt{n}}{\sqrt{m}} \right) \text{erfc} \left( \frac{y}{2 \sqrt{mt}} - \sqrt{nt} \right) \right. \\
+ \exp \left( \frac{y \sqrt{n}}{\sqrt{m}} \right) \text{erfc} \left( \frac{y}{2 \sqrt{mt}} + \sqrt{nt} \right) \\
+ \frac{y}{2 \sqrt{mn}} \left( 1 - 4n \right) \left[ \exp \left( -\frac{y \sqrt{n}}{\sqrt{m}} \right) \text{erfc} \left( \frac{y}{2 \sqrt{mt}} - \sqrt{nt} \right) \right. \\
- \exp \left( \frac{y \sqrt{n}}{\sqrt{m}} \right) \text{erfc} \left( \frac{y}{2 \sqrt{mt}} + \sqrt{nt} \right) \right]
\]

\[ - \frac{y \sqrt{t}}{2 \sqrt{mn \sqrt{nt}}} \exp \left( -\frac{y^2}{4 \sqrt{nm t}} - nt \right)
+ \frac{A_1}{2} \left[ \exp \left( -\frac{y \sqrt{n}}{\sqrt{m}} \right) \text{erfc} \left( \frac{y}{2 \sqrt{mt}} - \sqrt{nt} \right) \right. \\
+ \exp \left( \frac{y \sqrt{n}}{\sqrt{m}} \right) \text{erfc} \left( \frac{y}{2 \sqrt{mt}} + \sqrt{nt} \right) \right]
\]

\[ + A_2 \left[ \left( \frac{t}{2} - \frac{c}{4 \sqrt{n}} \right) \exp \left( -\frac{y \sqrt{n}}{\sqrt{m}} \right) \text{erfc} \left( \frac{y}{2 \sqrt{mt}} - \sqrt{nt} \right) \right. \\
+ \left( \frac{t}{2} + \frac{c}{4 \sqrt{n}} \right) \exp \left( \frac{y \sqrt{n}}{\sqrt{m}} \right) \text{erfc} \left( \frac{y}{2 \sqrt{mt}} + \sqrt{nt} \right) \right]
\]

\[ + A_3 e^{\alpha t} \left[ \exp \left( -\frac{y \sqrt{a + n}}{\sqrt{m}} \right) \text{erfc} \left( \frac{y}{2 \sqrt{mt}} - \sqrt{(a + n)t} \right) \right. \\
+ \exp \left( \frac{y \sqrt{a + n}}{\sqrt{m}} \right) \text{erfc} \left( \frac{y}{2 \sqrt{mt}} + \sqrt{(a + n)t} \right) \right]
\]

\[ + \frac{A_4}{2} \left[ \exp \left( -\frac{y \sqrt{n}}{\sqrt{m}} \right) \text{erfc} \left( \frac{y}{2 \sqrt{mt}} - \sqrt{nt} \right) \right. \\
+ \exp \left( \frac{y \sqrt{n}}{\sqrt{m}} \right) \text{erfc} \left( \frac{y}{2 \sqrt{mt}} + \sqrt{nt} \right) \right] \]
\[+A_5 \left\{ \frac{t}{2} - \frac{c}{4\sqrt{n}} \exp \left( -\frac{y\sqrt{n}}{\sqrt{m}} \right) \text{erfc} \left( \frac{y}{2\sqrt{mt}} - \sqrt{nt} \right) \right. \\
\left. + \left( \frac{t}{2} + \frac{c}{4\sqrt{n}} \right) \exp \left( \frac{y\sqrt{n}}{\sqrt{m}} \right) \text{erfc} \left( \frac{y}{2\sqrt{mt}} + \sqrt{nt} \right) \right\} \\
+ \frac{A_6 e^{at}}{2} \left[ \exp \left( -\frac{y\sqrt{a+n}}{\sqrt{m}} \right) \text{erfc} \left( \frac{y}{2\sqrt{mt}} - \sqrt{(a+n)t} \right) \\
+ \exp \left( \frac{y\sqrt{a+n}}{\sqrt{m}} \right) \text{erfc} \left( \frac{y}{2\sqrt{mt}} + \sqrt{(a+n)t} \right) \right] \\
+ \frac{A_7}{2} \left[ \exp \left( -\frac{y\sqrt{R}}{\sqrt{m}} \right) \text{erfc} \left( \frac{y\sqrt{P_r}}{2\sqrt{t}} - \sqrt{\frac{R}{P_r}} t \right) \\
+ \exp \left( \frac{y\sqrt{R}}{\sqrt{m}} \right) \text{erfc} \left( \frac{y\sqrt{P_r}}{2\sqrt{t}} + \sqrt{\frac{R}{P_r}} t \right) \right] \\
+ \frac{A_8}{2} \left\{ \frac{t}{2} - \frac{P_r y}{4\sqrt{R}} \exp \left( -\frac{y\sqrt{R}}{\sqrt{m}} \right) \text{erfc} \left( \frac{\sqrt{P_r} y}{2\sqrt{t}} - \sqrt{\frac{R}{P_r}} t \right) \\
+ \left( \frac{t}{2} + \frac{P_r y}{4\sqrt{R}} \right) \exp \left( -\frac{y\sqrt{R}}{\sqrt{m}} \right) \text{erfc} \left( \frac{\sqrt{P_r} y}{2\sqrt{t}} + \sqrt{\frac{R}{P_r}} t \right) \right\} \\
+ \frac{A_9 e^{at}}{2} \left[ \exp \left( -\frac{y\sqrt{R} + aP_r}{\sqrt{m}} \right) \text{erfc} \left( \frac{\sqrt{P_r} y}{2\sqrt{t}} - \sqrt{a + \frac{R}{P_r}} t \right) \\
+ \exp \left( \frac{y\sqrt{R} + aP_r}{\sqrt{m}} \right) \text{erfc} \left( \frac{\sqrt{P_r} y}{2\sqrt{t}} + \sqrt{a + \frac{R}{P_r}} t \right) \right] \\
+ \frac{A_{10}}{2} \left[ \text{erfc} \left( \frac{\sqrt{S_c}}{2\sqrt{t}} \right) + \text{erfc} \left( \frac{\sqrt{S_c}}{2\sqrt{t}} \right) \right] \\
+ \frac{A_{11}}{2} \left[ \left( \frac{t}{2} - \frac{\sqrt{S_c}}{4} \right) \text{erfc} \left( \frac{\sqrt{S_c}}{2\sqrt{t}} \right) + \left( \frac{t}{2} + \frac{\sqrt{S_c}}{4} \right) \text{erfc} \left( \frac{\sqrt{S_c}}{2\sqrt{t}} \right) \right] \\
+ \frac{A_{12} e^{at}}{2} \left[ \exp \left( -\frac{y\sqrt{aS_c}}{\sqrt{m}} \right) \text{erfc} \left( \frac{\sqrt{S_c}}{2\sqrt{t}} - \sqrt{at} \right) \\
+ \exp \left( \frac{y\sqrt{aS_c}}{\sqrt{m}} \right) \text{erfc} \left( \frac{\sqrt{S_c}}{2\sqrt{t}} + \sqrt{at} \right) \right] \right] \quad (19) \]
4. Results and Discussion

The focus of study is likely determining the impacts of radiation on the intensity and mass transport properties of MHD. For various values of flow parameters like the Prandtl number (Pr), Schmidt number (Sc), and thermal radiation parameter (R), the Casson fluid flow and numerical results of velocity (U), temperature (T), and concentration (C) with the boundary layer were determined. The values listed below typically determine the parameters.

In these conditions, higher mass grazing numbers encourage higher velocity levels and stronger convective motion.

Figure 2 shows the plotted velocity profiles for a range of mass Grashof numbers. When all other contributing factors are held constant, the curve of the velocity profile against span-wise coordinate g is shown in the figure. The ratio of the species buoyant force to the viscous hydrodynamic force is defined by the mass Grashof number. It has been noted that as the mass Grashof number grows, so increase the velocity.

In Figure 3 Higher flow velocities may result from more vigorous convective movement triggered by an increase in the thermal Grashof number. Higher thermal Grashof numbers indicate stronger buoyancy-driven flow, which can result from wider temperature differences or more variations in the fluid’s properties (density). This is why this phenomenon happens. In conclusion, stronger convective motion may be caused by a rise in the thermal Grashof number, which could lead to higher flow velocities.

The effects of transverse velocity on the magnetic field parameter M are shown in Figure 4, as with axial velocity, it is shown that the transverse velocity rises with decreasing values of M.

![Figure 2. Profiles of velocity for distinct Gm values having Gr=5, Sc=2.01, R=4, Pr=0.71, M=0.6, k=0.5, \( \lambda = 0.35 \), t = 1.1](image-url)
Fig. 3. Velocity profiles for distinct Gr values having Sc=2.01, Pr=0.71, R=4, M=0.6, k=0.5, $\lambda = 0.35$, t = 1.1

Fig. 4. Velocity profiles for distinct M values having Gm=5, Sc=2.01, Gr=5, Pr=0.71, R=4, $k = 0.5$, $\lambda = 0.35$, t = 1.1

The fluctuation of the velocity profiles with the Casson fluids parameter is displayed in Figure 5. It is observed that there is a marked consequence of raising values of $\lambda$ on the velocity distribution within the boundary layer. It is observed that the velocity profiles rise with raising $\lambda$ values.
The effect of the Pr on velocity profiles is demonstrated in Figure 6. It is found that a rise in the Prandtl number leads to declines in the velocity profiles. The Prandtl number's effect on speed is dependent on the relevant movement conditions and thermal transfer mechanisms. In some cases, particularly in forced convection flows where heat transfer is significant.

Figure 7 illustrates how the Schmidt number Sc affects the velocity profiles. It is evident that when Sc values rise, the fluid's velocity drops. This can be attributed to the fact that increasing Sc causes a decline in molecular diffusivity, which results in a drop in the velocity boundary layer thickness as well as concentration.
The fluctuation of the velocity profiles with porous medium parameter $K$ is exhibited in Figure 8. It is found that the fluid velocity rises with raising the value of pirogue medium parameter. This occurs as a result of buoyancy force, which increases fluid velocity and thickness in the “boundary layer” as $k_1$ rises.

The effect of thermal radiation number $R$ on the profiles of velocity is revealed in Figure 9. It could be found that the fluid velocity decreases with decrement of rising values of the thermal radiation parameter.
Figure 10 displays how the Sc impacts the profiles of concentration. The concentration drops as the Schmidt number increases. A drop in molecular diffusivity, which in turn causes a drop in the concentration boundary layer, is the physical consequence of a rise in the Schmidt number.

The concentration profile is displayed in Figure 11 as a function of the time parameter t,(0.4,0.5,0.6) As the time parameter t increases, the concentration profiles become larger.

Figure 12 shows how temperature profiles affect different time values (0.5, 0.6, 0.7) It is noted that when t increases, the wall temperature rises as well.
In Figure 13 examined the temperature response to the Prandtl number is influenced by flow behaviour and boundary conditions. In some cases, a higher Prandtl number can result in less thermal mixing, going to result in higher temperature gradients.

In Figure 14 displayed the effect of radiation on temperature is dependent on the system and the conditions under investigation. In general, higher radiation values can have a greater impact on radiative heat transfer. In the preceding example, as radiation values increase, the temperature curve decreases.
Fig. 13. Profiles of temperature for distinct (Pr) values with t=0.5, R=2

Fig. 14. Temperature profiles for various R values having Pr=0.71, t=0.5

5. Conclusion

The current study investigated the free convection MHD flow of a viscous, chemically reactive, electrically conducted, incompressible, and Casson fluid past a parabolically accelerated vertical plate, as well as the transfer of heat and mass in the incidence of thermal radiation. We obtain exact solutions and numerical results for the fluid flow through the vertical plate described above under the condition of a transverse constant M. The Laplace transform method is used to close the concentration and temperature in order to find the numerical solution of velocity. Using detailed graphics, the effects of the governing parameters—time, Pr, Gr, and Gm—are examined. The following analytical description is given for the concentration, temperature, and velocity profiles.
i. Raising the thermal radiation (R) parameter causes the temperature to decrease, but raising the time (t) causes the temperature to rise.

ii. The concentration values are considered high when the Sc decreases, the level rises, and the time elapses.

iii. The velocity rises as Gr, Gm. Additionally, when Sc and Pr increase in value, the velocity lowers. As the M parameter and rotational parameter (λ) are raised, the velocity moves up.

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