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FREE CONVECTION OF MAGNETO CASSON NANOFLUID IN PRESENCE OF ACCELERATED PLATE WITH CHEMICAL REACTION

Ms. A. DALLY MARIA EVANGELINE Assistant Professor Department of Mathematics Don Bosco College (Co-Education) (Affiliated to Thiruvalluvar University) Guezou Nagar, Athanavur Yelagiri Hills Tirupattur District. Pin Code – 635 853

ABSTRACT

The current paper's goal is to investigate the incompressible casson naofluid's unsteady boundary levelstream, heat and mass transferal properties across a uniformly accelerated salver in the occurrence of a chemical response. The fundamental governing equivalences are transformed into non-linear differential equivalences by expending similarity conversions. These equations have a solution. With the use of a graph, the influence of the fluid's numerous physical characteristics is examined, and conclusions are drawn as a result.

Key Words:
Mageto Casson naofluid, Hall current, Non-Newtonian fluid, Chemical reaction

Introduction:

The most significant function in fluid mechanics theory is played by non-Newtonian fluids. Non-Newtonian fluids are defined as those whose shear tension besides shear proportion are non-linear. The Non-Newtonian fluids include blood, food grease, toothpaste, and others. Because the basic parts of nanomaterials are smaller than or equal to the size of de Broglie wave, these materials are recognised as novel energy sources [23]. Utilising nanoparticles is currently the subject of numerous investigations. The Brownian motion and associated thermophoresis characteristics are to blame. Nanofluids are a newly recognised class of heat transfer fluids. The pedestal fluids' portrayal of heat transmission is enhanced by the introduction of nanoparticles [6]. Most non-Newtonian liquid forms in the works study were examined using basic representations similar the power rulebesidesrating2 or 3 [1,12,13,20,21, 22,24]. These unpretentious fluid representations require flaws that lead to findings that are uncertainly at odds with fluid movements.

Alternative liquid representation aimed at non-Newtonian liquid is the Casson fluid. For a number of materials, it is intermittently verified the Casson fluid representation convulsions rheological statistics recovering than universal visco-plastic models [4,8,18]. Tomato pulp, jelly, soup, honey besides precise fruit let extracts are a few examples of Casson fluids. Another substance that can be regarded as Casson fluid is human blood. Humanoid red lifeblood cells are recognized as aggregation or rouleaux because of the existence of several constituents asprotein, fibrinogen and globulin fashionable aqueous disreputable plasma. A succumb strain is identifiable with the steady revenuetension in Casson's liquid exists if the rouleaux behaves like a malleablehard [8,9,15].

In order to create nanofluids, nanoparticles such as nitrides, metallic carbides and carbon nanotubes are suspended trendy heat-trading liquids (such as oil, aquatic, ethylene glycol polymer proposal and biofluids); the sincere conductivity of the liquids depends significantly onluminosityprofessionmeasurementamongst the luminosityoccupation surface and the glow trade medium. Particles narrower than 100 nm are called nanoparticles. By demonstrating how an approach to extending the glow conversion standard is the employment of denseelements as extra materialadjournedhooked on the improperliquids. In light of this, nanofluid is a very compelling method for improving heat exchange. A review of the restrict stratumtributary of nano-fluids in excess of a affectingseeming in a spilled liquid was conducted by Bachok et al. [2]. Their findings show that when both the platter andunrestrictedtorrent travel in opposite course, there are double game options.

Nanofluid has several applications such as surface covering, biomedical, transportation, equipment cooling, and more. The study of the formation of electrically coordinated fluids governed by related attractive properties is known as magnetohydrodynamics, or MHD. Bondareva: [3]. The problem of transitory assorted convective laminar point of confinement stratumtorrent ofdissipative,thick, incompressible, electrically synchronizing nano-fluid commencing a dependable augmentation susceptible superficialexclusive observing attractive meadow and earnestcontamination flow was introduced by Ferdows et al. [9]. As stated by Hail and Shankar [10], heat besides mass flow in extremeargument layer torrent of unhinged sticky nano-fluid alongside a perpendicularaugmentationexpanseclassified observing attractive warm contamination, meadow, warm period and artificial rejoinder. Hady et al. [11] analyse a statistical analysis of a characteristic convection approximately theperpendicular cone inserted in non Darcian nano-fluid comprising gyro-tactic bacteria flooding penetrable media. Beginning late, Jashim Uddin et al. [14] examined the computational analysis of Stefan blustering the various slide consequences ofaelegancedetermined bioconvection nano-fluid tributary including microbes.

A numerical investigation is conducted into the problem of a nanofluid's breaking point layer stream passing beyond a growing sheet. Khan [16]. In order to investigate magneto laminar infringementargumentstratumtributarythrough warmth and mass exchange of an electrically synchronizing water-based nano-fluid including gyrotactic microbesbeside a convectively get along with enhancing area, Khan and Makinde [17] employed Oberbeck-Boussinesq character and resemblancedeviations.

In the direction ofrecognising the non-Newtonian liquid performance, one uses Casson liquidprototypical. The Casson liquid is characterised as a shear-thinning liquescent with theendless gluiness of zero trimlevel, a returntensionbeneath which no currenttranspires, and the zero viscidness ofimmeasurable shear proportion [7, 19]. The aforementioned has been determined the nonlinear Casson's constitutive equation accurately characterises the currentbends of pigment postponements in the lithographic processes recycled to prepare silicon suspensions [25] and printing inks [26]. Completed the broad assortment of trimproportions, the characteristics of several polymers are satisfactorily designatedthrough the trim stress-shear amountrelative provided by the Casson [5].

The rheological equivalence of theceremonial aimed at the isotropic and incompressible current of the Casson liquid is by way oftracks [5]

$$\tau_{ij} = \begin{cases} 2\left(\mu_B + \dfrac{P_y}{\sqrt{2\pi}}\right)e_{ij}, & \pi > \pi_c \\ 2\left(\mu_B + \dfrac{P_y}{\sqrt{2\pi_c}}\right)e_{ij}, & \pi < \pi_c \end{cases}$$

where $\pi = e_{ij}e_{ij}$ and e_{ij} are the $(i,j)th$ constituent ofdistortionproportion, π isartifact of the constituent of distortiondegreethroughthemself, π_c is theprecariousassessment of this item for consumptionconstructed in non-Newtonian prototypical, μ_B is the hardenergetic viscosity of non-Newtonian liquid and P_y is produceanxiety of liquid.

In order to create dependable, affordable besidescomprehensiblestrategies that stand tailored towards the necessary solicitation, the industrial sector has a huge demand for various ways or strategies for enhancing the mass and heattransferencethrough chemical response in numerous fields. The effects of mass, heat, chemicalresponse, Soret quantitybesides Schmidt quantitythrough Hall result in a homogeneouslyaugmentedplatter for the casson nano fluid have not yet been specifically studied. Therefore, the current analysis's goal is to investigate how mass, heat, chemical response, Soret numeral, Schmidt numeralbesides Hall outcome all work together to affect an MHD problem for a casson nonofluid in a plate that is evenly accelerated.

Mathematical model:

Incompressible electrically accompanying the Casson Nano-liquidpreceding an infinite vertical smooth plate conquering the plane y $= 0$ is considered. The gesture of the platter is taken in x-axis and z – axis lying onplatter normal to both x and y – axis. Primarily it is presumedasplates remain at the similar temperature Tbesides concentration Cuniversally in the liquid. By the side of time $t > 0$, the platterjerksaffectingimprudentlythrough the unvarying velocity in thespecific plane alongside the x-axis. Similarly the temperature besides concentration of the plate is raised/lowered. Theunvarying magnetic ground,equivalent to y - axis is executed.

The governing equations are

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

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=\left(1+\frac{1}{\beta}\right)\frac{\partial^2 u}{\partial y^2}+g[\beta_t(T-T_\infty)-\beta_c(C-C_\infty)]\,cos\,\omega-\left[\frac{\sigma}{\rho}(E_oB_o-B_o^2u)\right]-Fu^2(2)$$

$$u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}=\alpha\frac{\partial^2 T}{\partial y^2}-\frac{1}{(\rho\bar{c})_f}\frac{\partial q_r}{\partial y}+\tau\left[D_B\frac{\partial C}{\partial y}\frac{\partial T}{\partial y}+\frac{D_T}{T_\infty}\left(\frac{\partial T}{\partial y}\right)^2\right]+\frac{Q_o}{\rho c_p}(T-T_\infty)+\frac{\sigma}{\rho c_\rho}(uB_o-E_o)^2(3)$$

$$u\frac{\partial C}{\partial x}+v\frac{\partial C}{\partial y}=\left(D_B\frac{\partial^2 C}{\partial y^2}\right)+\left(\frac{D_TK_T}{T_\infty}\right)\frac{\partial^2 T}{\partial y^2}-R^*(C-C_\infty)(4)$$

The following boundary conditions are applied to the governing equations mentioned above:

when $y=0$

$$u=U_w(x)=cx,\ v=V_w\ ,T=T_w,\ N=-m_0\frac{\partial u}{\partial y},\ C=C_w$$

And when $y=\infty$

$$u\rightarrow 0,\ v\rightarrow 0,\ T\rightarrow T_\infty,\ N\rightarrow 0,\ C\rightarrow C_\infty$$

The similarity transformation which are used in the governing equations to obtain transformed equations are,

$$u=cxf'(\eta),\ v=-\sqrt{cv}f(\eta),\ \eta=y\sqrt{\frac{c}{v}},\ \theta(\eta)=\frac{T-T_\infty}{T_w-T_\infty},\ \phi(\eta)=\frac{C-C_\infty}{C_w-C_\infty}$$

Transformed equations using similarity transformation,

$$\left(1+\frac{1}{\beta}\right)f'''+ff''-f'^2+(Gr_x\theta+Gc_x\phi)\cos\omega-M[E_1-f']-F_rf'^2=0(5)$$

$$Pr_N\theta''+f\theta'+N_b\phi'\theta'+N_t\theta'^2+E_c(f'')^2+ME_c(f'-E_1)^2=0(6)$$

$$\phi''+Lef\phi'+SrLe\theta''-LeR\phi=0(7)$$

Boundary conditions of the transformed equations are,

If $\eta=0$

$$f(\eta)=S,\ f'(\eta)=1,h(\eta)=0,\theta(\eta)=1,\phi(\eta)=1. \quad (8)$$

And if $\eta=\infty$

$$f'(\eta)\rightarrow 0,\ h(\eta)\rightarrow 0,\ \theta(\eta)\rightarrow 0,\ \phi(\eta)\longrightarrow 0. \quad (9)$$

Results and Discussion:

In addition to the boundary conditions (8) and (9), the nonlinear equations (5) through (7) are unravelled arithmetically exhausting the MATLAB bvp4c technique. The belongings of innumerable physical restrictions arranged the flow field are visually examined by us. These profiles are displayed: the concentration, temperature, and velocity profiles. The following outcomes are derived from the graph.

To provide a clear understanding of the problem, the figures show how the velocity, temperature, and concentration components are affected by the following factors: magnetic consideration, casson factor, Grashoff numeral, modified Grashoff numeral, electric factor, chemical responsefactor, Prandtl number, Brownian motion factor, Lewis numeral, Soret numberbesides Eckert numeral.

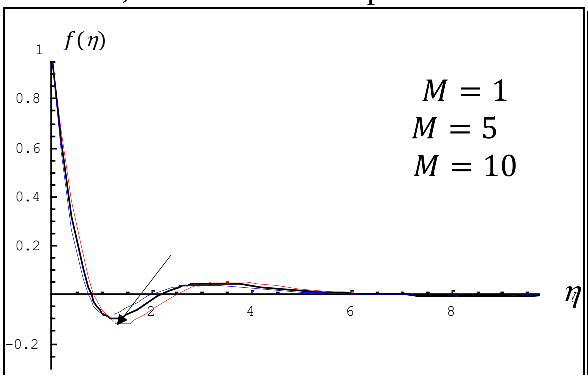
Figures 1 and 2 illustrate how a rise in the casson parameter raises the velocity profile while a fall in the Hartmann number decreases it. A Lorentz force's general propensity to resist the gesticulation of the electrically accompanyingliquid is seen by primary velocity decreasing the magnetic factor in the boundary layer escalations. Nonetheless, in the thin boundary layer adjacentto platter boundary, velocity rises in size as the magnetic number increases, and inincidence of the magnetic arena, the reversing current acts like a primary velocity.

In proportion to the Grashoff number, the velocity profile falls, and in proportion to the modified Grashoff number, it increases. Three and four figures illustrate this outcome. The swiftnesscirculation in normal convection is analysed using the Grashof number. The buoyant force resulting from the longitudinaldissimilarity in liquidcompactness divided by the viscidpower is known as the Grashof number. In a positive meaning, the Grashof number denotes the cooling effect in proximity to the plate.

The graphic indicates that the secondary velocity is greatly impacted and flows at an accelerated pace, whereas the main velocity is slowed in its velocity. Figure 5 demonstrates the influence of the electric field parameter on the rapidityoutline. The rapiditycontour drops as the electric field strength rises, as seen by the graph. A chemical reaction's impact on fluid movement is seen in Figure 6. The evidence indicates that as chemical reactions intensify, so does fluid velocity.

The temperature profile is shown against the Hall, Brownian motion, and Prandtl numbers in Figures 9–11. In proportion to prandtl numeral, the infectionsketch rises, whereas in proportion to the Nb and, it decreases. Given that the momentum equation's Boussinesq's approximation assumes a linear relationship between the fluid's density and temperature, the extent of currentborderlinedeposit grows through the Prandtl numeral drops. For the reason that temperature and velocity are linked. Both velocity and temperature will exhibit similar kinds of behaviour.

The figures numbered 10 through 14 show the concentration profile versus different fluid parameters. The concentration profile diminishes as the Lewis number, chemical reaction parameter, Soret number, Eckert number, and Prandtl number rise. For higher levels of Lewis number and Soret number, the concentration profile diminishes since these numbers rely on mass diffusivity and thermal diffusivity. An important factor affecting the concentration profile is the Prandtl numeral, which ispercentage of momentum diffusivity to current diffusivity. For rising Prandtl number standards, the concentration profile thus decreases.



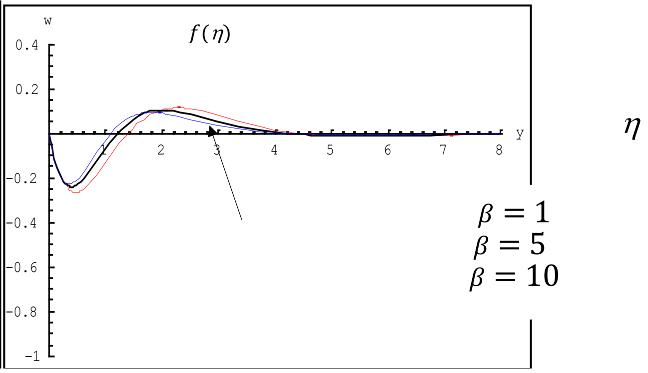
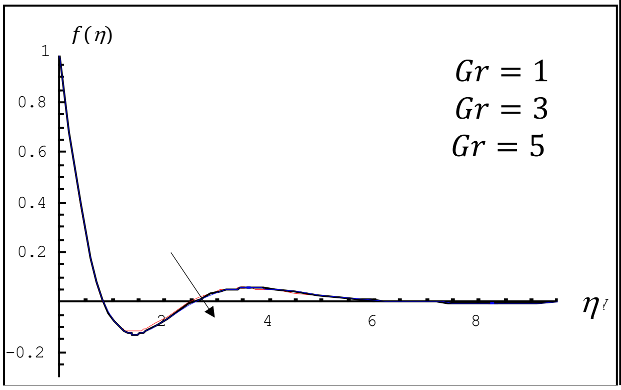


Figure 1 Velocity profile for diverse values of M **Figure 2 :** Velocity profile for diverse values of β



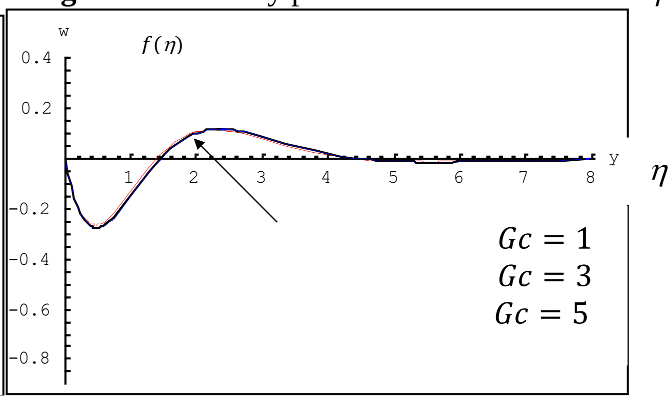
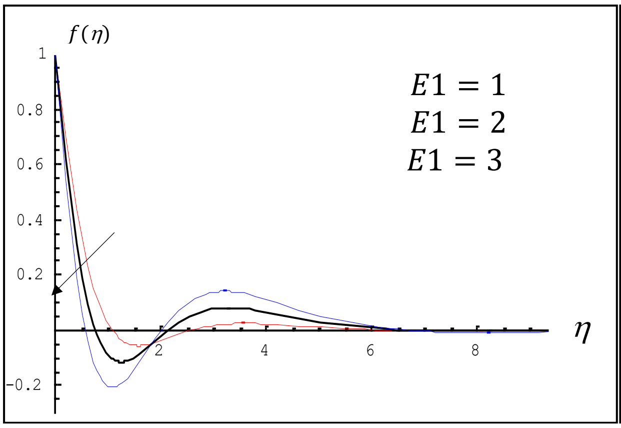


Figure 3 : Velocity profile for diverse values of Gr **Figure 4 :** Velocity profile for diverse values of Gc



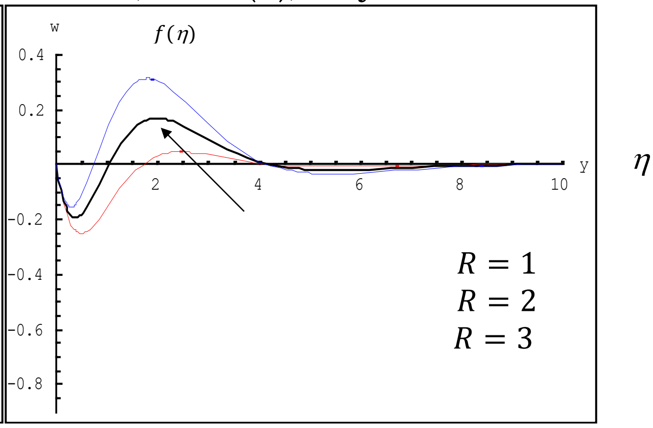
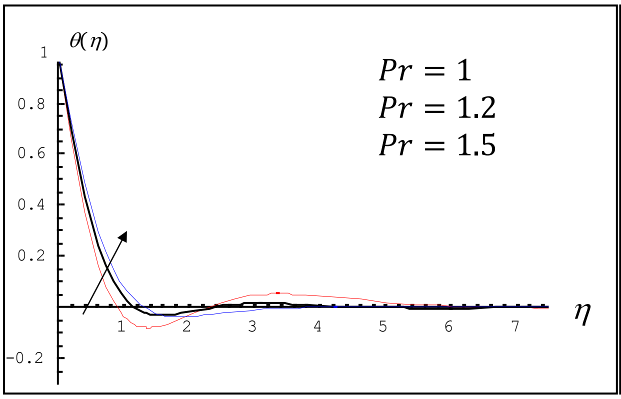


Figure 5 : Velocity profile for diverse values of $E1$**Figure 6 :** Velocity profile for diverse values of R



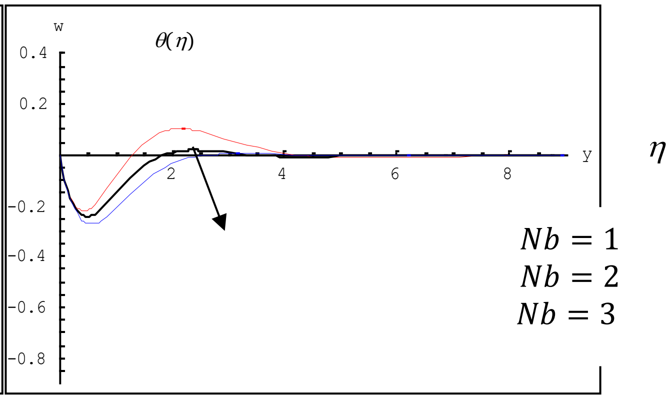
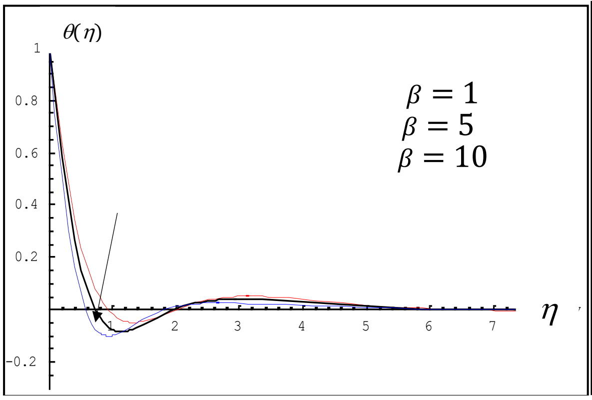


Figure 7 : Temperature profile for diverse values of Pr**Figure 8 :** Temperature profile for diverse values of Nb



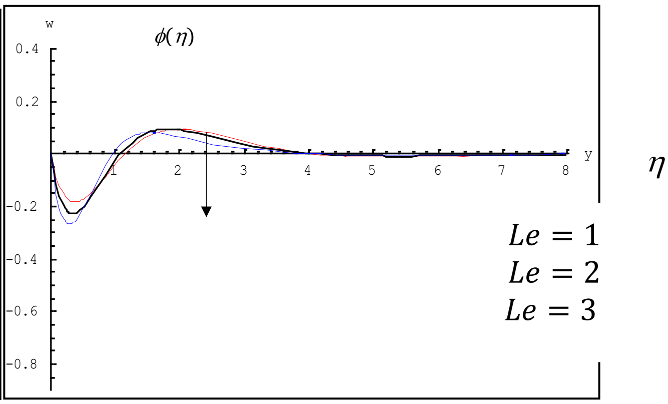
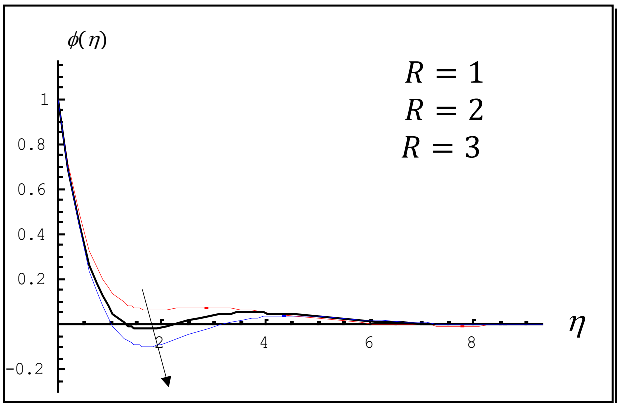


Figure 9 : Temperature profile for diverse values of β**Figure 10 :** Concentration profile for diverse values of Le



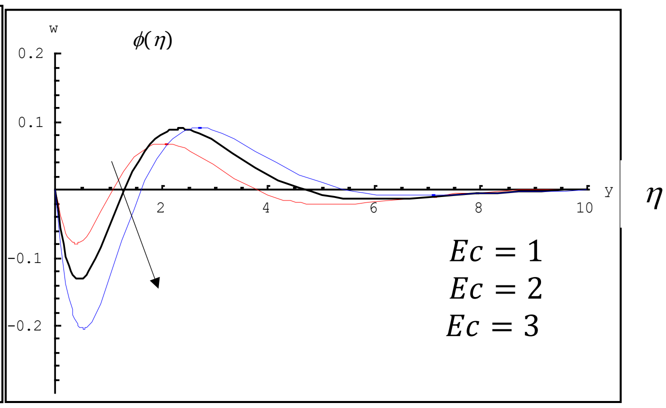
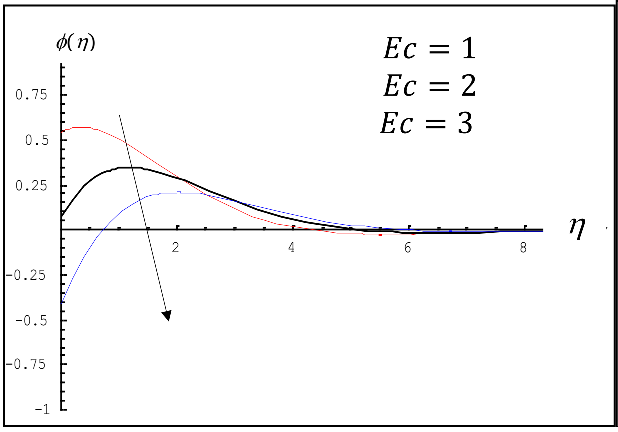


Figure 11: Concentration profile for diverse values of R **Figure 12:** Concentration profile for diverse values of Sr



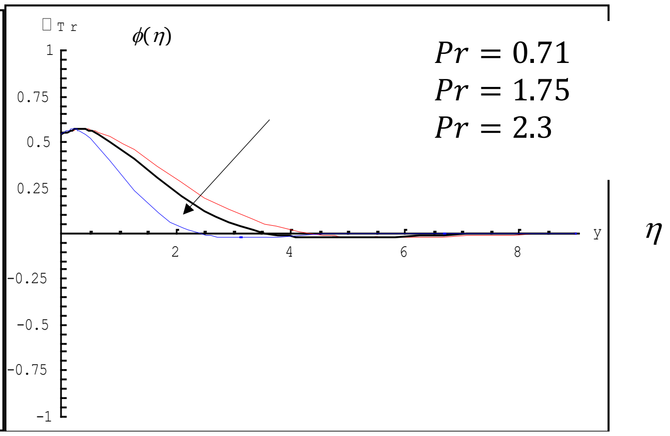


Figure 13: Concentration profile for diverse values of Ec **Figure 14 :** Concentration profile for diverse values of Pr

Conclusion:

This paper discusses magneto casson nanofluid free convection in occurrence of an accelerating plate besides chemical response. To resolve the ODEs, MATLAB Bvp4c is utilised. An illustrated representation shows how planted factors affect the velocity, heat, and mass functions. The main conclusions are stated. While the casson parameter, modified grashoff number, and chemical reaction parameter accelerate fluid velocity, the magnetic, electric, and grashoff number have a retarding effect. As prandtl numeral rises, temperature sketch decreases, and as the Brownian motion besides casson parameter rise, the temperature profile grows. Increases in Lewis number, chemical responserestriction, Soret numeral, Eckert numberbesides Prandtl numeral cause a drop in the concentration profile.

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