Journal of Mines, Metals and Fuels, *71(12): 2837-2847; 2023. DOI: 10.18311/jmmf/2023/41943*

Print ISSN : 0022-2755

Journal of Mines, Metals and Fuels

Contents available at: *www.informaticsjournals.com/index.php/jmmf*

Soret Effect on Mixed Convection of Casson Fluid Flow in Presence of Porous Media in a Porous Channel

P. A. Dinesh[1]*, M. S. Gayathri[2], K. V. Suma[3], B. V. Shilpa[4] and D. V. Chandrashekhar[4]

[1]Department of Mathematics, Ramaiah Institute of Technology, Bangalore - 560 054, Karnataka, India; dineshdpa@msrit.edu

[2]Department of Mathematics, B.M.S College of Engineering, Bangalore - 560 019, Karnataka, India; msgayathri.maths@bmsce.ac.in

[3]Department of Electronics and Communication, Ramaiah Institute of Technology, Bangalore - 560 054, Karnataka, India; sumakv@msrit.edu

[4]Department of Mathematics, Vivekananda Institute of Technology, Bangalore - 560 074, Karnataka, India; shilpabvsr@gmail.com, dvchandru@gmail.com

Abstract

The purpose is to investigate the impact of Soret on free and mixed convective Casson fluid flow in presence of amplification in a porous channel with magnetic field is carried out analytically. The obtained are coupled PDEs are highly nonlinear and are converted to an ODEs by similarity transformation and further solved by using perturbation technique to obtain velocity, concentration and temperature equations of the physical system. The influence of non-dimensional parameters such as Prandtl number Pr, Schmidt number Sc, thermal buoyancy parameter λ, Reynolds number R, chemical reaction rate γ, concentration buoyancy parameter N, Darcy number Da, Casson fluid parameter β, Hartmann number M^2, Soret effect Sr on velocity, thickness of fluid and heat have been discussed with graphs. The few important computational outcomes reveal that the Soret effect Sr enriches the concentration, fluid flow and temperature of fluid whereas Casson fluid parameter β diminishes the profiles. The earlier work and present work have been compared in the absence of Soret effect and is establishes to be good contract.

Keywords: *Casson fluid, Perturbation Technique, Porous Channel, Porous Media and Soret effect*

1.0 Introduction

In recent decades, the non-Newtonian Casson fluid gained very importance due to its widespread range of uses. Casson has many uses in metallurgy, biomechanics, food processing, manufacturing of drilling, pharmaceutical products, paints, china clay, synthetic lubricants, bioengineering operations and polymer processing industries. Soret effect has a vital role in transfer of mass and heat of fluid, due to this many researchers have been attracted towards it. Flux is the rate of flow per unit area, the energy flux is caused by temperature and composition gradients. Soret effect or thermo diffusion is a process of transfer of mass due to temperature gradient. These effects have gained importance in the following areas geosciences, hydrology, petroleum industry etc. Suresh Kumar *et al.*[1] observed the Soret effect and chemical reaction by considering 2D unsteady convection flow on a vertical plate. Employed Crank-Nicolson scheme to solve the constituent equations numerically. Further, Soret parameter and chemical reaction effect have been discussed on flow and thickness of the fluid. Reddy *et*

**Author for correspondence*

al.[2] analysed Casson convection flow with Hall and Soret effect in a channel.

Chalavadi Sulochana *et al.*[3] analysed 3D MHD Casson fluid with of source or sink of heat, Soret effect and thermal radiation on a stretching sheet. Hari *et al.*[4] inspected the generation of heat and thermal diffusion effect on magneto hydrodynamic Casson fluid flow about the vertical fluctuating plate in occurrence of thermal radiation, chemical reaction and porous medium. Laplace transform methods is implemented to solve the equations analytically. Further, computational work has been done by using Matlab. Bhatti[5] studied the thermal diffusion combined with thermal radiation effect on Williamson nanofluid on porous extending sheet. The dimensionless equations have been obtained by using Chebyshev spectral collection method and successive linearization methods. Marija[6] investigated the redistribution of active element between the layers in presence of Soret effect. The effect and relation of Lewis number thermo diffusion have been discussed. An incompressible, viscous, mixed convection of fluid over the heated plate with different fluid properties with Dufour Soret parameter had been carried out by Nalinakshi *et al.*[7].

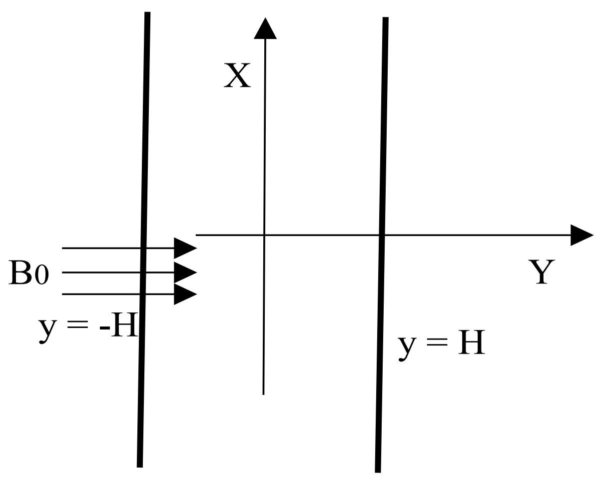
Charan *et al.*[8] analysed magneto hydrodynamic flow of Casson fluid in occurrence of source or sink on a vertical plate with Soret effect. Girinath Reddy *et al.*[9] investigated the effect of Soret-Dufour with different properties of fluid over the surface. Suresh *et al.*[10] examined Soret and dufour effect over mixed convective electrically conducting fluid on a plate in occurrence magnetic field. ODE have been obtained by similarity transformation and shooting technique. Girinath Reddy *et al.*[11] considered the mixed convection flow of fluid with Dufour - Soret parameter with different properties of fluid on a moving surface. Shooting technique have been carried out to find solution to the governing equations. Kavitha *et al.*[12] considered the variation of fluid on boundary layer with porous medium. Further, studied the effect of second order resistance. Suneetha *et al.*[13] analysed the impact of Soret parameter on viscous, incompressible flow of unsteady free convection fluid in existence of heat source and thermal radiation on a plate. Further, physical parameters effect have been studied on temperature, Nusselt number, coefficient of skin friction, Sherwood number, velocity and concentration. Vijaya *et al.*[14] surveyed the physical properties of Casson fluid in a vertical wall with radiation, transverse magnetic field, chemical reaction, constant heat source and porous medium. Runge-Kutta-Fehlberg method followed by shooting method have been implemented to resolve the constitutive equations. Baskar *et al.*[15] used convection for secondary refrigerants in order to transfer the heat in which CNT is used as nanofluid and base fluid is EG.

Couette flow of dusty viscoelastic fluid in a canal to study Soret-Dufour effect and radiation absorption have been considered by Uma *et al.*[16]. Vijaya *et al.*[17] inspected magnetohydrodynamic Casson fluid flow in existence of Soret effect, chemical reaction and radiation on the porous vertical plate. Two-term perturbation methods have been applied to get the solution analytically and results have been discussed graphically. Krishnandan *et al.*[18] reviewed the influence of Soret parameter on laminar, steady magnetohydrodynamic Newtonian fluid flow on rotating porous disk using Forchheimer model. The dimensional equations have been resolved numerically by applying similarity transformation. Forchheimer model was considered by Nalinakshi *et al.*[19] for electrically conducting fluid in existence of Dufour-Soret effect on a plate. Vijaya *et al.*[20] observed the Soret effect on 2D steady magnetohydrodynamic flow of free convective Casson fluid in existence of thermal radiation over the moving vertical plate. Further, dimensionless parameters effect have been discussed on concentration, velocity and temperature profiles. Shilpa *et al.*[21] investigated mixed convection flow of Casson in occurance of amplification in a porous medium. Cletus *et al.*[22] studied the Williamson liquid along the stretching porous sheet in existence of Soret effect, viscous dissipation, chemical reaction and radiation to transfer mass and heat. Spectral homotopy analysis method have been implemented to resolve the obtained equations. Magneto hydrodynamic fluid flow with variable viscosity on the surface is carried by Girinath Reddy *et al.*[23] to transfer mass and heat. Vidyashree *et al.*[24] investigated impact of variability of convective ferromagnetic fluid in a porous layer with magnetic field dependent viscosity in presence of gravity field.

The work discussed in the above section are related to the study of Soret effect on free or forced convection or mixed convection of Casson fluid or any non-Newtonian or Newtonian fluid in presence of porous medium or without porous medium in different channel. With these literatures an attempt is made to study free and forced convection flow of Casson fluid in a vertical channel in occurrence of Soret effect, porous medium and amplification.

2.0 Mathematical Formulation

A laminar, incompressible, steady MHD flow of Casson fluid in a vertical porous channel with porous medium, amplification and Soret effect as an external agent such that the two-dimensional model is having one wall of vertical channel at y = H and another wall is at y = -H is considered. Laterally the centerline of the channel x-axis is situated and perpendicular to it is Y-axis. At y = H the fluid is injected and is pulled out at y = -H with uniform velocity V. B_0 is strength of magnetic field which is maintained perpendicular to the velocity field. The magnetic field induced is insignificant compared with imposed magnetic field.



Physical Configuration

The physical system has the following governing equations

Continuity equation:

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

Momentum equation:

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=-\frac{1}{\rho}\frac{\partial p}{\partial x}+\upsilon\left(1+\frac{1}{\beta}\right)\frac{\partial^2 u}{\partial y^2}-\frac{\sigma {B_0}^2 u}{\rho}-\frac{\mu_p}{k2}u\pm g\left(\beta_C(C-C_2)+\beta_T(T-T_2)\right) \tag{2}$$

$$u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}=-\frac{1}{\rho}\frac{\partial p}{\partial y}+\upsilon\left(1+\frac{1}{\beta}\right)\frac{\partial^2 v}{\partial x^2}-\frac{\mu_p}{k2}v \tag{3}$$

Equation of energy:

$$u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}=\frac{k}{\rho C_p}\frac{\partial^2 T}{\partial y^2} \tag{4}$$

Equation of species:

$$u\frac{\partial C}{\partial x}+v\frac{\partial C}{\partial y}=D\frac{\partial^2 C}{\partial y^2}-Ck_1+\frac{D_m K_T}{T_m}\frac{\partial^2 T}{\partial y^2} \tag{5}$$

Where ρ is density of the fluid, u, v are components of velocity in x and y direction, β is Casson fluid parameter, p is the pressure, g is the acceleration due to gravity, υ is kinematic viscosity, B_0 is uniform magnetic field, β_C is concentration expansion coefficient, β_T is thermal expansion coefficient, k is thermal conductivity, σ is electrical conductivity, T is temperature of the fluid, μ is dynamic viscosity, D is mass diffusion, C_p is specific heat at constant pressure, k_1 is reaction rate, k2 is porous permeability and C is concentration field.

The below mentioned equation is obtained, from (2) and (3).

$$u\frac{\partial^2 u}{\partial x\partial y}+\frac{\partial u}{\partial x}\frac{\partial u}{\partial y}+v\frac{\partial^2 u}{\partial y^2}+\frac{\partial v}{\partial y}\frac{\partial u}{\partial y}-u\frac{\partial^2 v}{\partial x^2}-\frac{\partial v}{\partial x}\frac{\partial u}{\partial x}-\frac{\partial v}{\partial y}\frac{\partial v}{\partial x}-v\frac{\partial^2 v}{\partial y\partial x}=\upsilon\left(\frac{1}{\beta}+1\right)\left(\frac{\partial^3 u}{\partial y^3}-\frac{\partial^3 v}{\partial x^3}\right)-\left(\frac{\sigma B_0^2}{\rho}+\frac{\mu_p}{k2}\right)\frac{\partial u}{\partial y}+\frac{\mu_p}{k2}\frac{\partial v}{\partial x}\pm\frac{\partial g}{\partial y}[\beta_T(T-T_2)+\beta_C(C-C_2)] \tag{6}$$

2.1 Boundary Conditions

$$v=V/2,\ u=0,\ C=C_2,\ T=T_2,\ \text{at } y=H$$

$$v=0,\ \frac{\partial u}{\partial y}=0,\ C=C_1,\ T=T_1,\ \text{at } y=0. \tag{7}$$

2.2 Non – dimensionalisation

Equation (4), (5) and (6) are non-dimentionalized by (8).

$$x^*=\frac{x}{H},\quad y^*=\frac{y}{H},\ v=aVf(y^*),\ u=-Vx^*f'(y^*),$$

$$\theta(y^*)=\frac{T-T_2}{T_1-T_2},\ \phi(y^*)=\frac{C-C_2}{C_1-C_2} \tag{8}$$

Equation (4), (5) and (6) are non-dimensionalized to get below mentioned concentration, temperature, velocity equations respectively.

$$\phi'' - aSc\, f\phi' - Sc\, \gamma\, (\phi + A) + \varepsilon\, Sc\, Sr\, \theta'' = 0 \tag{9}$$

$$\theta'' - aPrf\, \theta' = 0 \tag{10}$$

$$\left(\frac{1}{\beta} + 1\right) f'''' - (Da + M^2) f'' + \varepsilon R[(2 - a) f'' f' - a f''' f] \pm \lambda[\theta' + N\phi'] = 0 \tag{11}$$

Where $\lambda = \dfrac{Gr_x}{R^2}$ is the thermal buoyancy parameter, $M^2 = \dfrac{\sigma B_0^2 H^2}{\mu}$ is Hartmann number,

$Gr_x = \dfrac{VH^4 g \beta_T (T_1 - T_2)}{x\upsilon^3}$ is Grashof number,

concentration of buoyancy parameter is $N = \dfrac{\beta_C (C_1 - C_2)}{\beta_T (T_1 - T_2)}$

$R = \dfrac{VH}{\upsilon}$ is Reynolds number, chemical reaction rate $\gamma = \dfrac{k_1 H}{\upsilon}$, Schmidt number $Sc = \dfrac{HV}{D}$,

$Pr = \dfrac{\rho C_p HV}{k}$ is Prandtl number,

$Da = \dfrac{\mu_p H^2}{k\upsilon}$ is Darcy number,

β is Casson fluid parameter, 'a' is amplification and

$Sr = \dfrac{D_m\, K_T (T_1 - T_2)}{T_m VH (C_1 - C_2)}$ is Soret number.

Equation (7) under boundary conditions (8) reduces to (12),

$$f(1) = \frac{1}{2}, \theta(1) = 0, f(0) = 0, f''(0) = 0, \quad \phi(0) = 1, \phi(1) = 0, \theta(0) = 1, f'(1) = 0. \tag{12}$$

3.0 Solution of the Problem

Perturbation method is employed to find solution of above equations and assumed concentration ϕ, temperature θ and velocity f equation solutions are given below

$$\phi = \phi_{01} + \varepsilon * \phi_{02} + a1 * \phi_{11} + \varepsilon * a1 * \phi_{12}, \tag{13}$$

$$\theta = \theta_{01} + \varepsilon * \theta_{02} + a1 * \theta_{11} + \varepsilon * a1 * \theta_{12}, \tag{14}$$

$$f = f_{01} + \varepsilon * f_{02} + a1 * f_{11} + \varepsilon * a1 * f_{12}, \tag{15}$$

Perturbation parameters 'a1' and 'ε' have been introduced for double perturbation technique to obtain (16), (17) and (18) as concentration, temperature and velocity equations when (9), (10) and (11) subjected to (13), (14) and (15) respectively.

$$\begin{aligned}
\phi = {} & d_4 e^{d_3 y} + d_5 e^{-d_3 y} - A + \varepsilon \left(d_{29}\, e^{d_3 y} + d_{30} e^{-d_3 y}\right) \\
& a1\, \varepsilon\, (d_{278} e^{d_3 y} + d_{279} e^{-d_3 y} + d_{414}\, y e^{d_3 y} + d_{415}\, y\, e^{-d_3 y} \\
& + d_{416} e^{2d_3 y} + d_{419} y^2 e^{-d_3 y} + d_{420} e^{d_{36} y} + d_{421} e^{d_{38} y} \\
& + d_{422} e^{d_{35} y} + d_{423} e^{d_{37} y} + d_{424} y e^{d_{36} y} + d_{389} e^{d_8 y} \\
& + d_{425}\, y\, e^{d_{35} y} + d_{426}\, y\, e^{d_{37} y} + d_{427}\, y\, e^{d_{38} y} + d_{428} y^3\, e^{d_3 y} \\
& + d_{429}\, y^3 e^{-d_3 y} + d_{351}\, y^4\, e^{d_3 y} + d_{355} y^4 e^{-d_3 y} + d_{376} e^{d_{281} y} \\
& + d_{377} e^{d_{282} y} + d_{378} e^{d_{283} y} + d_{379} e^{d_{284} y} + d_{380} e^{d_{285} y} + d_{338} y \\
& + d_{381} e^{d_{286} y} + d_{382} e^{d_{287} y} + d_{383} e^{d_{288} y} + d_{384} e^{d_{289} y} \\
& + d_{385} e^{d_{290} y} + d_{386}\, e^{d_{291} y} + d_{391} y^2 + d_{394}\, y^2 e^{d_{36} y} \\
& + d_{398}\, y^2 e^{d_{38} y} + d_{410}\, y\, e^{2d_3 y} + d_{412}\, y\, e^{-2d_3 y} + d_{417} e^{-2d_3 y} \\
& + d_{418}\, y^2 e^{d_3 y} + d_{390} e^{-d_8 y} + d_{387} e^{3d_3 y} + d_{388} e^{-3d_3 y} + d_{430}) + \\
& a1\, \varepsilon\, (d_{278} e^{d_3 y} + d_{279} e^{-d_3 y} + d_{414}\, y e^{d_3 y} + d_{415}\, y\, e^{-d_3 y} \\
& + d_{416} e^{2d_3 y} + d_{419} y^2 e^{-d_3 y} + d_{420} e^{d_{36} y} + d_{421} e^{d_{38} y} \\
& + d_{422} e^{d_{35} y} + d_{423} e^{d_{37} y} + d_{424} y e^{d_{36} y} + d_{389} e^{d_8 y} \\
& + d_{425}\, y\, e^{d_{35} y} + d_{426}\, y\, e^{d_{37} y} + d_{427}\, y\, e^{d_{38} y} + d_{428} y^3\, e^{d_3 y} \\
& + d_{429}\, y^3 e^{-d_3 y} + d_{351}\, y^4\, e^{d_3 y} + d_{355} y^4 e^{-d_3 y} + d_{376} e^{d_{281} y} \\
& + d_{377} e^{d_{282} y} + d_{378} e^{d_{283} y} + d_{379} e^{d_{284} y} + d_{380} e^{d_{285} y} + d_{338} y \\
& + d_{381} e^{d_{286} y} + d_{382} e^{d_{287} y} + d_{383} e^{d_{288} y} + d_{384} e^{d_{289} y} \\
& + d_{385} e^{d_{290} y} + d_{386}\, e^{d_{291} y} + d_{391} y^2 + d_{394}\, y^2 e^{d_{36} y} \\
& + d_{398}\, y^2 e^{d_{38} y} + d_{410}\, y\, e^{2d_3 y} + d_{412}\, y\, e^{-2d_3 y} + d_{417} e^{-2d_3 y} \\
& + d_{418}\, y^2 e^{d_3 y} + d_{390} e^{-d_8 y} + d_{387} e^{3d_3 y} + d_{388} e^{-3d_3 y} + d_{430})
\end{aligned} \tag{16}$$

$$\begin{aligned}\theta &= d_1 + d_2 y + \varepsilon(d_{25} + d_{26} y)\\
&+a1\left(d_{16} + d_{17}y + d_{18}y^2 + d_{19}y^3 + d_{20}e^{d_8 y} + d_{21}e^{-d_8 y}\right.\\
&\left.+ d_{22}y^4 + d_{23}e^{d_3 y} + d_{24}e^{-d_3 y}\right) + a1\,\varepsilon(d_{161}y^3 + d_{162}y^4\\
&+ d_{193}y^5 + d_{204}e^{d_8 y} + d_{205}e^{-d_8 y} + d_{206}ye^{d_8 y} + d_{207}ye^{-d_8 y}\\
&+ d_{208}e^{d_3 y} + d_{209}e^{-d_3 y} + d_{210}ye^{d_3 y} + d_{211}ye^{-d_3 y}\\
&+ d_{167}e^{d_{36} y} + d_{160}y^2 + d_{212}y^2e^{d_3 y} + d_{213}y^2e^{-d_3 y}\\
&+ +d_{198}y^2e^{-d_8 y} + d_{210}y^2e^{d_8 y} + d_{168}e^{d_{35} y} + d_{133}y\\
&+ d_{169}e^{d_{37} y} + d_{170}e^{d_{38} y} + d_{171}e^{2d_3 y} + d_{172}e^{-2d_3 y}\\
&+ d_{187}e^{-2d_8 y} + d_{188}e^{2d_8 y} + d_{132})\end{aligned} \tag{17}$$

$$\begin{aligned}f &= d_9 + d_{10}y + d_{11}e^{d_8 y} + d_{12}e^{-d_8 y} + d_{13}y^2 + d_{14}e^{d_3 y} + d_{15}e^{-d_3 y} +\\
&\varepsilon\left(d_{50}y^2 + d_{71}y^3 + d_{33}e^{d_8 y} + d_{34}e^{-d_8 y} + d_{84}ye^{d_8 y}\right.\\
&+ d_{85}ye^{-d_8 y} + d_{86}e^{d_3 y} + d_{87}e^{-d_3 y} + d_{53}e^{2d_8 y} + d_{32}y\\
&+ d_{54}e^{-2d_8 y} + d_{55}e^{d_{36} y} + d_{56}e^{d_{35} y} + d_{57}e^{d_{37} y} + d_{58}e^{d_{38} y}\\
&+ d_{59}e^{2d_3 y} + d_{60}e^{-2d_3 y} + d_{31} + d_{64}y^2e^{d_8 y} + d_{69}y^2e^{-d_8 y}\\
&\left.+ d_{76}ye^{d_3 y} + d_{82}ye^{-d_3 y}\right) +\\
&a1\left(d_{216}e^{d_8 y} + d_{217}e^{-d_8 y} + d_{222}y^4 + d_{262}y^2 + d_{263}y^3\right.\\
&+ d_{224}ye^{d_8 y} + d_{225}ye^{-d_8 y} + d_{264}e^{d_3 y} + d_{265}e^{-d_3 y}\\
&+ d_{244}e^{2d_3 y} + d_{214} + d_{215}y + d_{266}ye^{d_3 y} + d_{267}ye^{-d_3 y}\\
&+ d_{268}y^2e^{d_3 y} + d_{269}\,y^2e^{-d_3 y} + d_{242}e^{d_{36} y} + d_{243}\,e^{d_{35} y}\\
&+ d_{245}e^{d_{38} y} + d_{246}e^{d_{37} y} + d_{247}e^{-2d_3 y} + d_{251}y^3e^{-d_3 y}\\
&\left.+ d_{258}y^3e^{d_3 y} + d_{226}y^5\right) +\\
&a1\varepsilon(d_{449} + d_{1027}ye^{-d_8 y} + d_{1029}e^{-d_3 y} + d_{1030}ye^{d_3 y}\\
&+ d_{1031}ye^{-d_3 y} + d_{1032}y^2e^{d_3 y} + d_{1033}y^2e^{-d_3 y} + d_{1034}y^3e^{d_3 y}\\
&+ d_{1035}y^3e^{-d_3 y} + d_{1040}ye^{d_{35} y} + d_{1041}ye^{d_{36} y} + d_{1042}ye^{d_{37} y}\\
&+ d_{1043}ye^{d_{38} y} + d_{1044}y^2e^{d_{35} y} + d_{1045}y^2e^{d_{36} y} + d_{1046}y^2e^{d_{37} y}\\
&+ d_{1047}y^2e^{d_{38} y} + d_{1037}ye^{d_{36} y} + d_{1038}ye^{d_{37} y} + d_{1048}y^2e^{d_8 y}\\
&+ d_{1049}y^2e^{-d_8 y} + d_{1050}y^3e^{d_8 y} + d_{770}y^6 + d_{1051}y^3e^{-d_8 y}\\
&+ d_{1052}y^4e^{d_8 y} + d_{1053}y^4e^{-d_8 y} + d_{1054}e^{2d_3 y} +\\
&d_{1055}e^{-2d_3 y} + d_{1056}ye^{2d_3 y} + d_{1057}ye^{-2d_3 y} + d_{1058}y^2e^{2d_3 y}\\
&+ d_{1059}y^2e^{-2d_3 y} + d_{1060}e^{2d_3 y} + d_{828}ye^{d_{290} y} + d_{824}ye^{d_{285} y}\\
&+ d_{986}y^3e^{d_{35} y} + d_{826}ye^{d_{287} y} + d_{827}ye^{d_{288} y} + d_{829}e^{d_{239} y}\\
&+ d_{931}y^5e^{d_8 y} + d_{942}y^5e^{-d_8 y} + d_{973}y^3e^{-d_3 y} + d_{993}y^3e^{d_{36} y}\\
&+ d_{833}e^{d_{455} y} + d_{834}e^{d_{456} y} + d_{835}e^{d_{457} y} + d_{972}y^3e^{2d_3 y}\\
&+ d_{863}y^4e^{d_3 y} + d_{874}y^4e^{-d_3 y} + d_{848}e^{d_{545} y} + d_{1039}e^{d_{38} y}\\
&+ d_{840}e^{d_{461} y} + d_{841}e^{d_{462} y} +\\
&d_{823}e^{d_{284} y} + d_{825}e^{d_{286} y} + d_{768}y^5 + d_{452}e^{-d_8 y} + d_{837}e^{d_{464} y}\\
&+ d_{838}e^{d_{459} y} + d_{839}e^{d_{460} y} + d_{1028}e^{d_3 y} + d_{846}e^{d_{540} y}\\
&+ d_{959}e^{3d_3 y} + d_{1025}y^4 + d_{452}e^{-d_8 y} + d_{847}e^{d_{541} y}\\
&+ d_{960}e^{-3d_3 y} + d_{1036}e^{d_{35} y} + d_{847}e^{d_{541} y} + d_{960}e^{-3d_3 y}\\
&+ d_{1036}e^{d_{35} y} + d_{832}e^{d_{454} y} + d_{83}e^{d_{291} y} + yd_{450} + d_{831}e^{d_{453} y}\\
&+ d_{842}e^{d_{463} y} + d_{836}e^{d_{458} y} + d_{845}e^{d_{544} y} + d_{1023}y^2\\
&+ d_{849}e^{d_{547} y} + d_{850}e^{d_{548} y} + d_{851}e^{d_{549} y} + d_{852}e^{d_{550} y}\\
&+ d_{853}e^{d_{280} y} + d_{855}e^{d_{282} y} + d_{451}e^{d_8 y} + d_{1240}y^3\\
&+ d_{1026}ye^{d_8 y} + d_{856}e^{d_{283} y}\end{aligned} \tag{18}$$

All the above solutions contains d_i terms are all constants, which are taking much space and not specified here.

4.0 Result and Discussion

Based on the physical configuration, the main equations of Casson fluid flow in a channel for mass and heat have been derived. The model is 2 dimensional model in which coordinates (x, y) have been transformed to one coordinate system by implementing similarity transformation. Next, an analytical approach is made using well known method called perturbation technique. The coupled PDEs are modified to ODEs with perturbation parameter 'a1' and 'ε'. Mathematica is used for the computation work. Further, temperature, concentration and velocity are discussed graphically on dimensionless parameters such as Hartmann number M_2, thermal buoyancy parameter λ, Casson fluid parameter β, Reynolds number R, concentration buoyancy parameter N, chemical reaction rate γ, amplification, Prandtl number Pr, perturbation parameter, Schmidt number Sc and Soret number.

Influence of Schmidt number (Sc) Figure 1 represents Sc effect on heat, thickness and flow. Because of diffusivity of momentum the profiles enhances with rise in Schmidt number.

Influence of Casson parameter (β) Figure 2 indicates influence of Casson fluid parameter (β) on thickness of fluid, heat and rate of flow of the fluid, the profiles reduces with surge in Casson parameter. Due to the inviscidness of fluid.

Influence of Darcy number (Da) Due to rise in permeability of porous medium the profiles enhances with increase in Da is observed in Figure 3.

Influence of thermal buoyancy parameter (λ) The rise in λ values diminishes the profiles is seen in Figure 4.

Hartmann number (M^2) effect The existence of Lorentz's force in the magnetic field acts against the flow, So the profiles diminishes which can be observed in Figure 5.

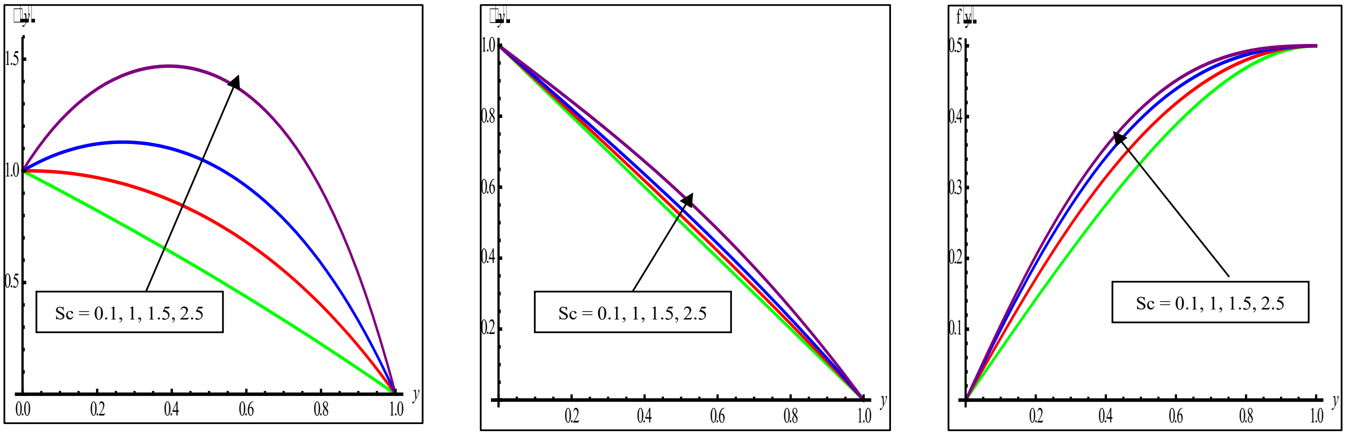


Figure 1. Schmidt number (Sc) effect on Concentration, Temperature and Velocity.

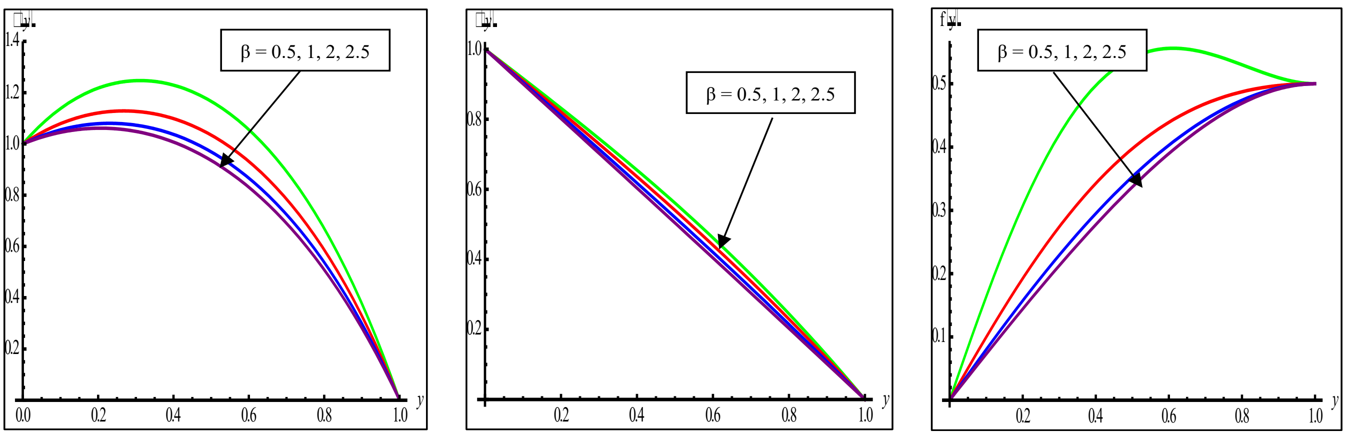


Figure 2. Concentration, Temperature and Velocity with Casson parameter (β).

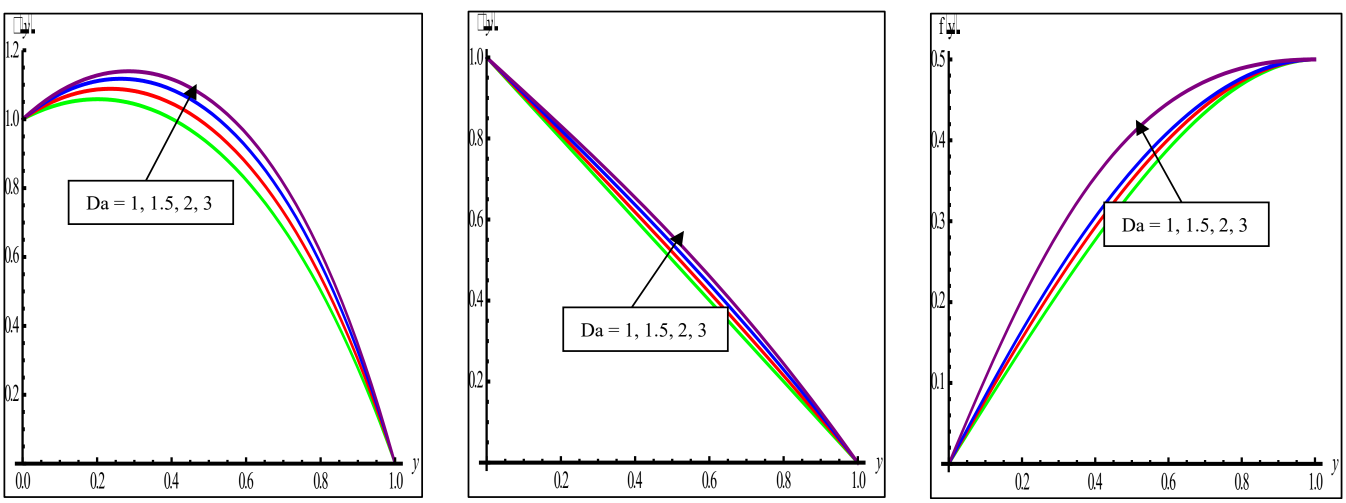


Figure 3. Concentration, Temperature and Velocity with Darcy number (Da).

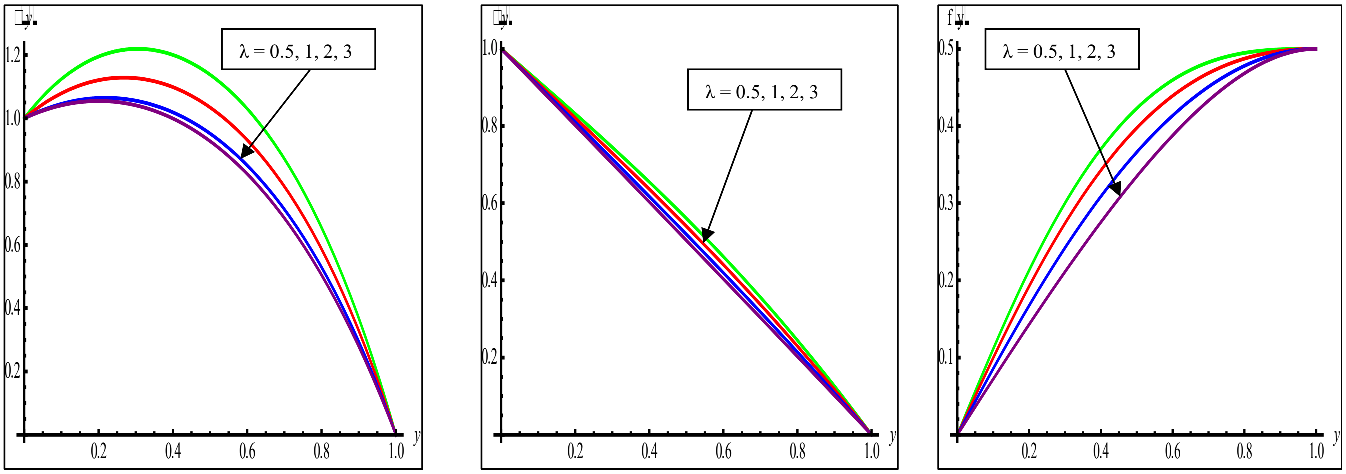


Figure 4. Thermal buoyancy parameter (λ) on Concentration, Temperature and Velocity.

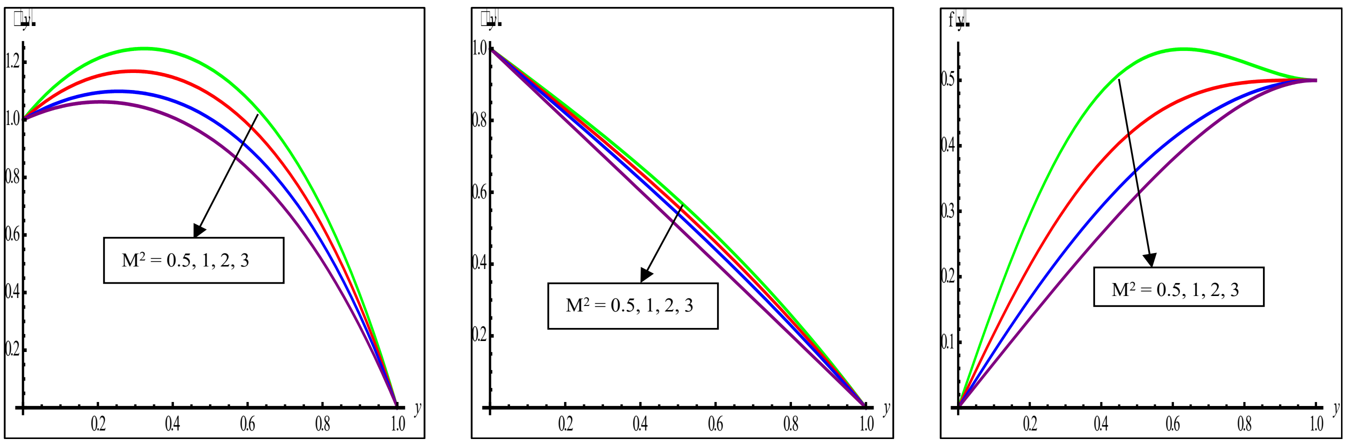


Figure 5. Concentration, Temperature and Velocity with Hartmann number (M^2).

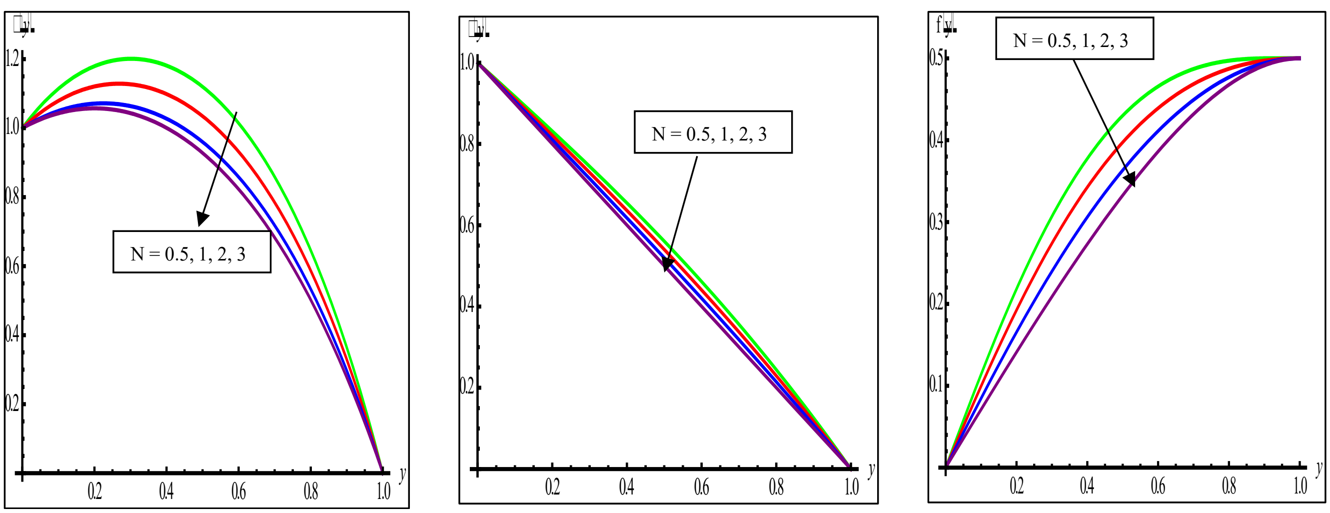


Figure 6. Concentration buoyancy parameter (N) on Concentration, Temperature and Velocity.

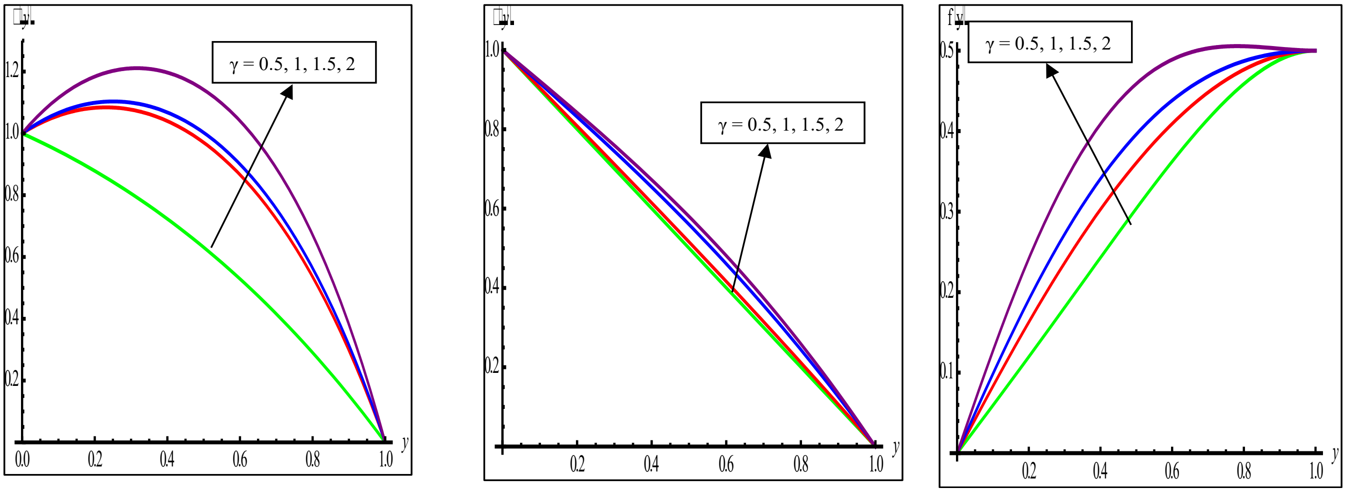


Figure 7. Concentration, Temperature and Velocity with Chemical reaction (γ).

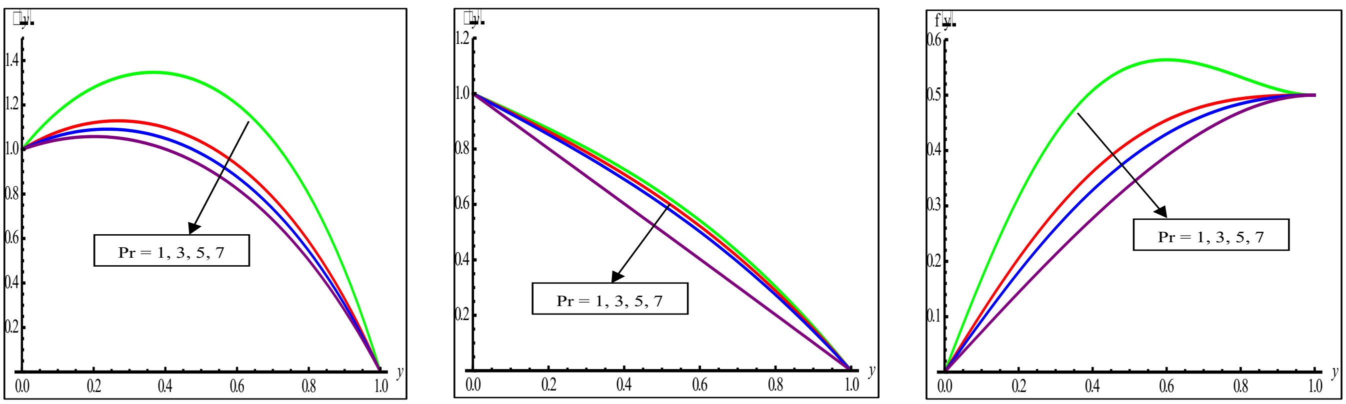


Figure 8. Concentration, Temperature and Velocity with Effect Prandtl number (Pr)

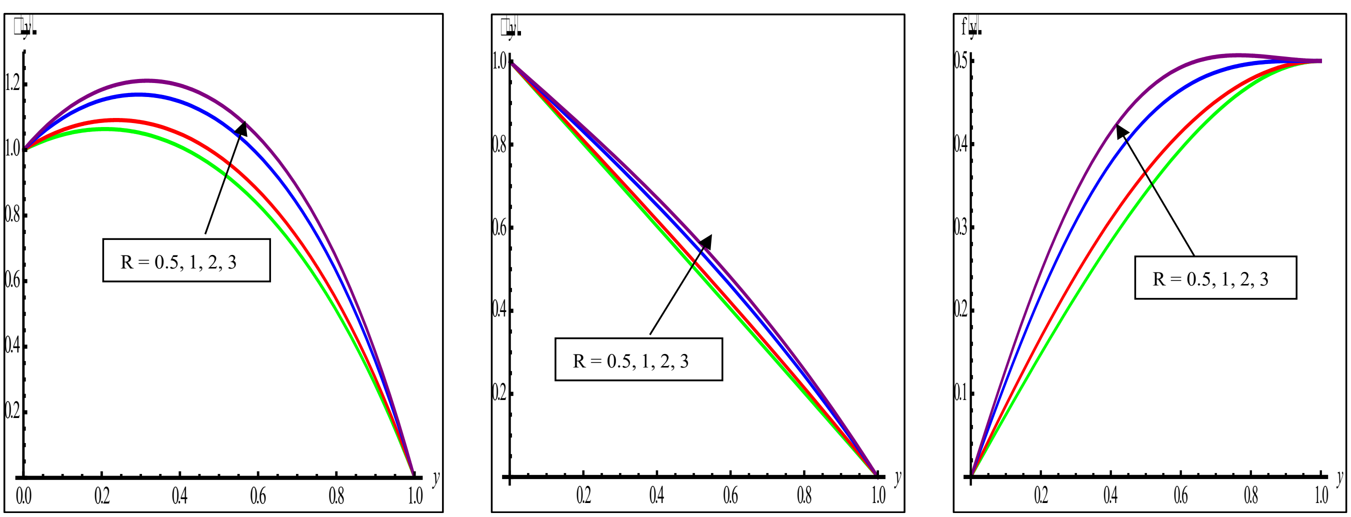


Figure 9. Reynolds number (R) on Concentration, Temperature and Velocity.

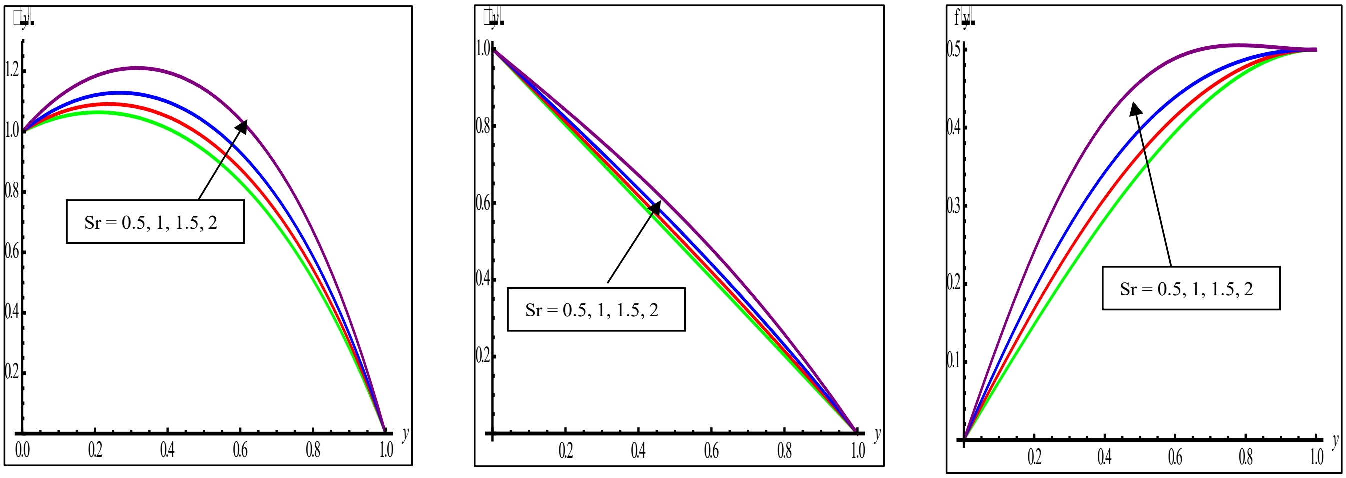


Figure 10. Concentration, Temperature and Velocity with Soret number (Sr).

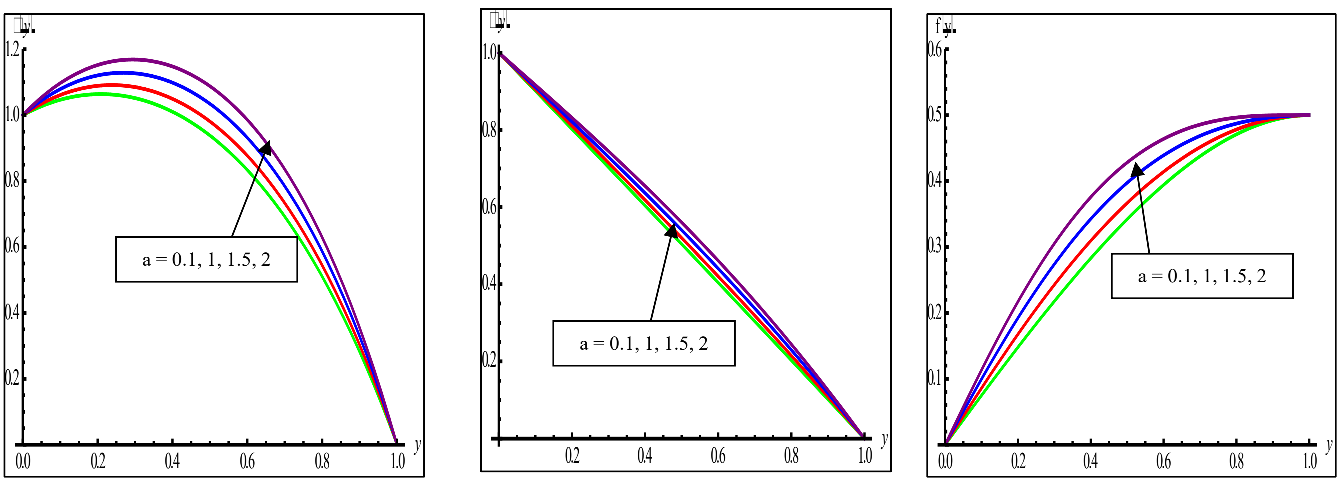


Figure 11. Concentration, Temperature and Velocity with Amplification (a).

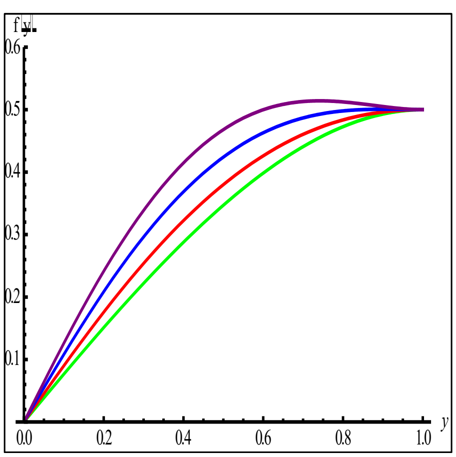


Figure 12. Velocity with Perturbation parameter (ε).

Impact of Concentration buoyancy parameter (N) It decreases the profiles is seen in Figure 6 with surge in N which is because of Soret effect.

Chemical reaction (γ) effect Due to exchange of molecules, chemical reaction (γ) enhances all the profiles can be seen in Figure 7.

Influence of Prandtl number (Pr) All the profiles diminishes with surge in Pr is noticed in Figure 8, fluid has high viscidness which declines the profiles.

Influence of Reynolds number (R) The rise in inertial forces decays the viscosity of fluid which leads to increase the Reynolds number, this in turn enhances the profiles is seen in Figure 9.

Influence of Soret number (Sr) Difference in temperature leads to the soret effect. The profiles develop with surge in Soret effect is represented in Figure 10.

Influence of amplification (a) All the profiles increases with surge in amplification is seen in Figure 11.

Influence of perturbation parameter (ε) Figure 12 represents effect of ε on velocity. As the perturbation parameter increases the profiles are also enhances rapidly but there is no much effect of ε on concentration and temperature profiles.

The above obtained results are having good comparision and agreement with earlier work of Shilpa *et al* [20] if Soret effect and Darcy number tends to zero.

5.0 Conclusion

Due to above assumptions, effect of dimensionless parameters on concentration, heat and velocity are discussed.

- Temperature, concentration and fluid flow diminishes with surge in Casson fluid parameter is because of high viscidness of fluid.
- Schmidt number enhances temperature, velocity and concentration distributions this is because of surge in momentum diffusivity.
- Growth in Darcy number enhances the profiles due to porosity of permeable medium.
- Concentration, temperature and velocity profiles diminishes with thermal buoyancy parameter because of Soret effect.
- The rise in Hartmann number reduces all profiles because of occurrence of Lorentz force.
- Prandtl number reduces the profiles due of high viscidness of fluid.
- Concentration buoyancy parameters declines the profiles because the domination of Soret effect.
- The surge in chemical reaction leads to grow the profiles because of exchange of molecules.
- Reynolds number enhances the profiles this is because of inertial forces which declines the viscosity.
- The growth in Soret number rises all the profiles this is because of difference in temperature.
- The rise in amplification enhances all the profiles.
- Perturbation parameter (ε) which is used for double perturbation influences in increase of velocity distributions.

6.0 Acknowledgement

The authors thank MSRIT, VKIT, BMSCE for their support.

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