IMPACTS OF THERMAL DIFFUSION AND CHEMICAL REACTION ON MHD JEFFERY FLUID FLOW PAST AN INCLINED POROUS PLATE

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ABSTRACT

This paper is concerned with the study of an unsteady MHD natural convective boundary layer flow of a viscous, incompressible and electrically conducting, Non-Newtonian Jeffrey fluid over an inclined permeable moving plate embedded in a porous medium in the presence of heat absorption, heat and mass transfer with Diffusion thermo and Thermal radiation. The equations governing the flow are transformed into a system of nonlinear ordinary differential equations by using perturbation technique. Graphical results for the velocity distribution, temperature distribution and concentration distribution based on the numerical solutions are presented and discussed. Also discuss the effects of various parameters on the skin-friction coefficient and the rate of heat transfer in the form of Nusselt number and rate of mass transfer in the form of Sherwood number at the surface. The resultant concentration enhances with increases diffusion thermo parameter, where as it shows reverse effect with increase in chemical reaction. The velocity distribution is observed to increase with an increase in the presence of permeability, where as it a show diminishes in the case of inclined and magnetic field parameter. The obtained numerical results reduce to previously published results on a special case of the problem.

Key Words: Heat transfer, Mass transfer, Porous media, Diffusion thermo, Radiation, Chemical reaction.

1. INTRODUCTION

Now-a-days, the examination of non-Newtonian liquid flows has become renowned for the reason of numerous applications in sciences and technical fields. Inspiration of researchers in these fluids is owed too many applications, precisely in food products, biological material and chemical material. Obviously, all non-Newtonian fluids are subjected to their effects happening within shear that are not specified by a single essential relationship. Consequently, few non- Newtonian fluids are instructed for the discussion relating to their many features. Non-Newtonian fluids are conferred through three chief classifications rate, differential and integral. The existing data witnesses that many studies given to the flow of different classes of many type materials. It is owed to focus that in several materials like shear and standard stresses are explained clearly in terms of velocity component. But, it is often not correct for two and three dimensional flows containing different classes of fluids. Currently, using Jeffrey fluid has grown in popularity for the modeling. It has a special influence of reduction and delay times. Few investigations show flow of Jeffrey fluid can be expressed. The authors [1, 2] have studied the nonlinear radially shrinking sheet through a permeable medium with MHD Jeffrey fluid. The examination reveals that the boundary layer thickness is studied in either stretching or shrinking sheet cases. Li et al. [3] have studied Effects of activation energy and chemical reaction on unsteady MHD dissipative Darcy–Forchheimer squeezed flow of Casson fluid over horizontal channel**.** Maatoug et al. [4] have analyzed Variable chemical species and thermo-diffusion Darcy–Forchheimer squeezed flow of Jeffrey nanofluid in horizontal channel with viscous dissipation effects. Recently Nagesh and Raghunath [5] have expressed Soret Radiation and Chemical Reaction effect on MHD Jeffrey fluid flow past an inclined vertical plate Embedded in porous medium. Akhil et al. [6] have analyzed Mixed convection micropolar ferro fluid flow with viscous dissipation, joule heating and convective boundary conditions. Akhil [7] studied Analysis of water-based composite MHD fluid flow using HAM. Quasim et al. [8] discussed heat and mass transfer in a Jeffrey fluid over a stretching sheet with heat source/sink.Sreenadh et al. [9] investigated peristaltic pumping of a fluid using power-law with Jeffrey fluid at the ending path with permeable walls.Zeeshan et al. [10] examined heat transfer analysis of Jeffery fluid flow over a stretching sheet with suction/injection and magnetic dipole effect. Naganthran et al. [11] investigated Effects of heat generation/absorption in the Jeffrey fluid past a permeable stretching/shrinking disc. Raghunath [12] has investigated Study of Heat and Mass Transfer of an Unsteady Magnetohydrodynamic Nanofluid Flow Past a Vertical Porous Plate in the Presence of Chemical Reaction, Radiation and Soret Effects. Akhil and Mittal [13] have studied radiation effects on unsteady 2D MHD Al_2O_3-water flow through parallel squeezing plates. Sheikholeslami et al. [14] have analyzed Radiation effects on heat transfer of three dimensional nanofluid flow considering thermal interfacial resistance and micro mixing in suspensions. Hari et al. [15] have possessed Influence of nonlinear radiation on MHD micropolar fluid flow with viscous dissipation. Hari et al. [16] have discussed Effect of nonlinear radiation on entropy optimized MHD fluid flow.

The radiation is the method used to study the heat transfer of material through a magnetic environment. The radiative convective flows may occur in almost all industrial processes. For instance, heating and cooling chambers, fuel combustion energy processes evaporation from massive open water reservoirs, etc. The term radiative plays a substantial role in the field of heat and mass transfer studies of a problem. Harshad [17] examined Thermal radiation effects on MHD flow with heat and mass transfer of micropolar fluid between two vertical walls. Harshad [18] reported Heat and mass transfer in MHD Casson fluid flow past over an oscillating vertical plate embedded in porous medium with ramped wall temperature. Effects of cross diffusion and heat generation on mixed convective MHD flow of Casson fluid through porous medium with non-linear thermal radiation discussed by Harshad [19]. Hsiao [20] presented that radiative and viscous dissipation impacts on an electrically MHD heat transfer thermal system by means of Maxwell fluid. The authors [21, 22] explained that the radiation and natural convection flow through with thermal radiation and mass transfer past a moving perpendicular permeable plate. Omar et al. [23] have studied Hall Current and Soret Effects on Unsteady MHD Rotating Flow of Second-Grade Fluid through Porous Media under the Influences of Thermal Radiation and Chemical Reactions. MHD Casson fluid flow through a vertical plate discussed by Parandhama et al. [24]. Srinivasacharya et al. [25] reported the radiation and chemical reaction effects upon mixed convection heat and mass transfer across a perpendicular plate inwards power-law fluid concentrated permeable medium. Pattnaik et al. [26] observed mass transfer and radiation effects upon MHD flow through a permeable medium past an exponentially accelerated disposed plate on flexible temperature. Luo et al. [27] contribute the influences of thermal radiation on MHD flow and heat transfer in a cubic cavity. Deepthi et al [28] have possessed Recent Development of Heat and Mass Transport in the Presence of Hall, Ion Slip and Thermo Diffusion in Radiative Second Grade Material. Murthy et al. [29] developed heat and mass transfer effects on MHD natural convective flow through a vertical permeable plate with thermal radiation and hall current. Sandya et al. [30] have proposed radiation and chemical reaction effects on MHD Casson fluid flow past a semi-infinite vertical moving porous plate. Sheikholeslami et al. [31] have studied Effect of thermal diffusion and heat-generation on MHD nanofluid flow past an oscillating vertical plate through porous medium. Hari and Akhil [32] have investigated Velocity, mass and temperature analysis of gravity-driven convection nanofluid flow past an oscillating vertical plate in the presence of magnetic field in a porous medium. Akhil and Hari [33] have possessed dimensional CuO–Water nanofluid flow considering Brownian motion in presence of radiation. Hari and Akhil [34] have reviewed Mathematical model for velocity and temperature of gravity-driven convective optically thick nanofluid flow past an oscillating vertical plate in presence of magnetic field and radiation.

The flow through a porous media could be a most interesting subject and it became emerging analysis for the explanation of heat and mass transfer in a wet medium which is incredibly related to nature and will even be used in many technical processes. Harshad [35] reported Cross diffusion and heat generation effects on mixed convection stagnation point MHD Carreau fluid flow in a porous medium. Effects of Magnetic field, thermo-diffusion and hall current on Casson fluid flow past an oscillating plate in porous medium studied by Harshad [36]. Pattnaik et al. [37] discussed the influence of Soret and Dufour with the hall current over instable hydro magnetic flow earlier in a vertical porous plate. Chamkha and Ahmed [38] have suggested similar description for unstable MHD flow exactly about a stagnation idea of three dimensional porous frame over the heat and mass transfer substance reaction and the heat generation. Harshad R. Patel [39] have discussed heat and mass transfer effects on unsteady free convective MHD flow of a micro polar fluid between two vertical walls. Raghunath and Mohanaramana [40] have examined Hall, Soret, and rotational effects on unsteady MHD rotating flow of a second-grade fluid through a porous medium in the presence of chemical reaction and aligned magnetic field. Sheikholeslami et al. [41] have studied Nanofluid heat transfer in a porous duct in the presence of Lorentz forces using the lattice Boltzmann method. Hari and Mittal [42] have studied Mathematical Analysis of three dimensional nanofluid flow in a rotating system considering thermal interfacial resistance and Brownian motion in suspensions through porous medium.

The novelty of this paper, we have studied the effects of various characteristics of heat and mass transfer on Jeffrey fluid in the presence of thermal radiation, heat generation, chemical reaction and thermal diffusion past an inclined plate. The objective of this study is to investigate analytically characteristics of MHD mixed convection flow of Jeffrey fluid past a radiating inclined permeable moving porous plate in the presence of heat absorption, Soret and chemical reaction. The uniqueness of this study is the consideration of well-known non-Newtonian fluid namely Jeffrey fluid past an inclined plate which is an extension of the work done by Nagesh et al.[5], who studied various flow characteristics of a Newtonian fluid. In the absence of Jeffrey parameter, the results of our study are in good agreement with the results of Nagesh et al. [5]. The study has importance in many metallurgical processes including magma flows, polymer and food processing, and blood flow in micro-circulatory system etc.

2. FORMULATION OF THE PROBLEM:

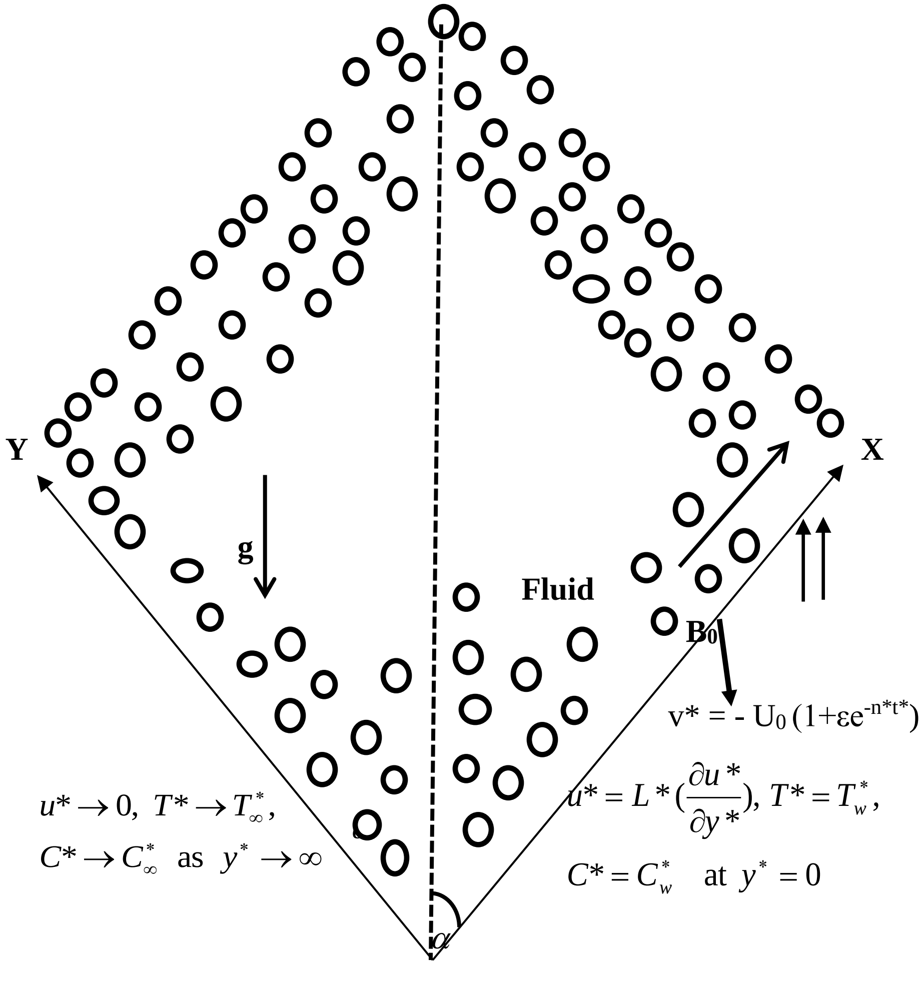

Figure: 1depicts the physical structure of the problem.

A two-dimensional insecure free convection stream of an incompressible thick liquid past an unbounded vertical permeable plate has been considered. In rectangular Cartesian organize framework, the x-axis is along the plate toward stream and the y-axis normal to it. Further, the stream is considered within the sight of temperature slope. In the investigation, the attractive Reynolds number is taken to be little with the goal that the actuated attractive field is dismissed. Moreover for little speed, the gooey dispersal and Darcy's dissemination are ignored. The stream in the medium is completely because of the lightness power brought about by a temperature contrast between the permeable plate and the liquid.

Under the above suppositions, the conditions administering the preservation of mass (continuity), force, vitality and fixation can be composed as followed by Nagesh al. [5].

$$\frac{\partial v^*}{\partial y^*} = 0 \tag{1}$$

$$\begin{aligned}\frac{\partial u^*}{\partial t^*} + v^*\frac{\partial u^*}{\partial y^*} &= \left(\frac{\vartheta}{1+\lambda}\right)\frac{\partial^2 u^*}{\partial y^{*2}} + g\beta_T (T^* - T_\infty^*)\cos\alpha \\ &\quad + g\beta_c (C^* - C_\infty^*)\cos\alpha - \frac{\sigma B_0^2}{\rho} u^* - \frac{\vartheta u^*}{K^*}\end{aligned} \tag{2}$$

$$\frac{\partial T^*}{\partial t^*} + v^*\frac{\partial T^*}{\partial y^*} = \frac{K_T}{\rho C_p}\frac{\partial^2 T^*}{\partial y^{*2}} - \frac{1}{\rho C_p}\frac{\partial q_r^*}{\partial y^*} - \frac{Q_1}{\rho C_p}(T^* - T_\infty^*) \tag{3}$$

$$\frac{\partial C^*}{\partial t^*} + V^*\frac{\partial C^*}{\partial y^*} = D\frac{\partial^2 C^*}{\partial y^{*2}} - K_c^*(C^* - C_\infty^*) + D_1\frac{\partial^2 T^*}{\partial y^{*2}} \tag{4}$$

The relevant boundary conditions are given as follows

$$\begin{aligned} &u^* = L^*\left(\frac{\partial u^*}{\partial y^*}\right), \quad T^* = T_w^*, \quad C^* = C_w^* \quad \text{at } y^* = 0 \\ &u^* \to 0, \qquad T^* \to T_\infty^*, \quad C^* \to C_\infty^* \quad \text{as } y^* \to \infty \end{aligned} \tag{5}$$

Where $L_1 = (2-M_x)/M_x$

The equation of continuity yields that V^* is either a constant or some function of time, hence it is assumed that

$$V^* = -U_0(1+\varepsilon e^{-n^*t^*}) \tag{6}$$

The negative sign indicates that the suction velocity acts towards the plate.

Consider the fluid which is optically thin with a relatively low density and the radioactive heat flux is given by as follows.

$$\frac{\partial q_r{}^*}{\partial y^*} = 4I^*(T^* - T_\infty^*) \tag{7}$$

The permeability of the porous medium in a non-dimensional form is considered as

$$K^* = K_0^*\,(1+\varepsilon e^{-n^*t^*}) \tag{8}$$

On introducing the following non-dimensional quantities,

$$u = \frac{u^*}{U_0}, y = \frac{U_0 y^*}{\vartheta}, \theta = \frac{T^* - T_\infty^*}{T_w^* - T_\infty^*}, \phi = \frac{C^* - C_\infty^*}{C_w^* - C_\infty^*}, \Pr = \frac{\mu C_p}{K_T}, Sc = \frac{\vartheta}{D}, M = \frac{\sigma B_0^2 \vartheta}{\rho U_0^2},$$

$$Gr = \frac{\vartheta g \beta_T (T_w^* - T_\infty^*)}{U_0^3}, Gm = \frac{\vartheta g \beta_c{}^* (C_w^* - C_\infty^*)}{U_0^3}, \quad k = \frac{U_0^2 K^*}{\vartheta^2}, t = \frac{t^* U_0^2}{4\vartheta}, h = \frac{U_0^2 L_1}{\vartheta},$$

$$K = \frac{\vartheta K_C^*}{U_0^2}, F = \frac{4I^*\vartheta}{\rho C_p v_0^2}, Q = \frac{Q_1 v}{U_0^2}, Sr = \frac{D_1 (T_w^* - T_\infty^*)}{\vartheta (C_w^* - C_\infty^*)}, R = \frac{4\vartheta n^*}{U_0^2}$$

The governing equations (1) to (4) can be rewritten in the non-dimensional form as follows

$$\frac{1}{4}\frac{\partial u}{\partial t} - (1+\varepsilon e^{-nt})\frac{\partial u}{\partial y} = \left(\frac{1}{1+\lambda}\right)\frac{\partial^2 u}{\partial y^2} + Gr\cos\alpha\,\theta + Gm\cos\alpha\,\phi - \left(M + \frac{1}{k}\right)u \tag{9}$$

$$\frac{\Pr}{4}\frac{\partial \theta}{\partial t} - \Pr(1+\varepsilon e^{-nt})\frac{\partial \theta}{\partial y} = \frac{\partial^2 \theta}{\partial y^2} - \Pr(\mathrm{F}+\mathrm{Q})\theta \tag{10}$$

$$\frac{Sc}{4}\frac{\partial \phi}{\partial t} - Sc(1+\varepsilon e^{-nt})\frac{\partial \phi}{\partial y} = \frac{\partial^2 \phi}{\partial y^2} - ScK + Sr\frac{\partial^2 \theta}{\partial y^2} \tag{11}$$

The corresponding boundary conditions are given by

$$\begin{aligned} &u = h\left(\frac{\partial u}{\partial y}\right), \quad \theta = 1, \quad \phi = 1, \quad at \quad y = 0 \\ &u \to 0, \quad \theta \to 0, \quad \phi \to 0 \quad as \quad y \to \infty \end{aligned} \tag{12}$$

3. SOLUTION OF THE PROBLEM

To tackle the partial differential Eqs (9), (10) and (11), we decrease them into conventional differential conditions. To get the arrangement we follow the methodology given by Gersten and Gross. In this manner the articulations for fluid velocity, temperature and focus are accepted in the accompanying structure.

$$u(y,t) = u_0(y) + \varepsilon u_1(y)e^{-nt}$$
$$\theta(y,t) = \theta_0(y) + \varepsilon\theta_1(y)e^{-nt}$$
$$\phi(y,t) = \phi_0(y) + \varepsilon\phi_1(y)e^{-nt} \tag{13}$$

Substituting the above expressions (13) in to Eqs (9), (10), (11) and equating the coefficient of ε^0, ε^1 (neglecting ε^2terms etc.,), we obtain the following set of ordinary differential equations

3.1. Zero order terms:

$$\frac{1}{(1+\lambda)}u_0'' + u_0' - \left(M + \frac{1}{k}\right)\mathrm{u}_0 = -\,\mathrm{Gr}\cos\alpha\ \theta_0 - \mathrm{Gm}\cos\alpha\ \phi_0 \tag{14}$$

$$\theta_0'' + \Pr\theta_0' - \Pr\left(F + Q\right)\theta_0 = 0 \tag{15}$$

$$\phi_0'' + Sc\ \phi_0' - \mathrm{ScK}\phi_0 = -\mathrm{S_r}\ \mathrm{Sc}\,\theta_0'' \tag{16}$$

3.2. First order terms:

$$\frac{1}{(1+\lambda)}u_1'' + u_1' + \left(M + n + \frac{1}{k}\right)\mathrm{u}_1 = -\,\mathrm{Gr}\cos\alpha\,\theta_1 - \mathrm{Gm}\cos\alpha\,\phi_1 - u_0' \tag{17}$$

$$\theta_1'' + \Pr\theta_1' + \left(\frac{\mathrm{nPr}}{4} - \left(F + Q\right)\Pr\right)\theta_1 = -\Pr\theta_0' \tag{18}$$

$$\phi_1'' + Sc\phi_1' + Sc\left(\frac{n}{4} - K\right)\phi_1 = -S_r Sc\theta_1'' - \mathrm{Sc}\phi_0' \tag{19}$$

The corresponding boundary conditions (12) reduce to

$$u_0 = h(\frac{\partial u_0}{\partial y}), u_1 = h(\frac{\partial u_1}{\partial y})\ ,\ \theta_0 = 1,\ \theta_1 = 0,\quad \phi_0 = 1, \phi_1 = 0 \qquad at \quad y = 0$$
$$u_0 \to 0, \qquad u_1 \to 0, \qquad \theta_0 \to 0, \theta_1 \to 0,\ \phi_0 \to 0, \phi_1 \to 0 \quad as \quad y \to \infty \tag{20}$$

Solving equations (14) – (19) under the boundary conditions (20), the following solutions are obtained

$$u_0 = \exp(-l_1 y) \tag{21}$$

$$\theta_0 = b_1\exp(-l_1 y) + b_2\exp(-l_2 y) \tag{22}$$

$$\phi_0 = b_3\exp(-l_1 y) + b_4\exp(-m_2 y) + b_5\exp(-l_3 y) \tag{23}$$

$$u_1 = b_6 \exp(-l_1 y) - b_6 \exp(-l_4 y) \tag{24}$$

$$\theta_1 = b_7 \exp(-l_1 y) + b_8 \exp(-l_2 y) + b_9 \exp(-l_4 y) + b_{10} \exp(-l_5 y) \tag{25}$$

$$\begin{aligned}\phi_1 = {} & b_{11} \exp(-l_1 y) + b_{12} \exp(-l_2 y) + b_{13} \exp(-l_3 y) \\ & + b_{14} \exp(-l_4 y) + b_{15} \exp(-l_5 y) + b_{16} \exp(-l_6 y)\end{aligned} \tag{26}$$

Substituting equations (21)–(26) in equation (13) we obtain the velocity temperature and concentration field

$$\begin{aligned}u(y,t) = {} & b_3 \exp(-l_1 y) + b_4 \exp(-m_2 y) + b_5 \exp(-l_3 y) + \varepsilon(b_{11} \exp(-l_1 y) + b_{12} \exp(-l_2 y) + \\ & b_{13} \exp(-l_3 y) + b_{14} \exp(-l_4 y) + b_{15} \exp(-l_5 y) + b_{16} \exp(-l_6 y))e^{-nt}\end{aligned} \tag{27}$$

$$\theta(y,t) = \exp(-l_1 y) + \varepsilon(b_6 \exp(-l_1 y) - b_6 \exp(-l_4 y))e^{-nt} \tag{28}$$

$$\begin{aligned}\phi(y,t) = {} & b_1 \exp(-l_1 y) + b_2 \exp(-l_2 y) \\ & + \varepsilon(b_7 \exp(-l_1 y) + b_8 \exp(-l_2 y) + b_9 \exp(-l_4 y) + b_{10} \exp(-l_5 y))e^{-nt}\end{aligned} \tag{29}$$

3.3. Skin Friction

$$\tau = \left(\frac{\partial u}{\partial y}\right)_{y=0} = -(l_1 b_3 + l_2 b_4 + l_3 b_5) - \varepsilon e^{-nt}(l_1 b_{11} + l_2 b_{12} + l_3 b_{13} + l_4 b_{14} + l_5 b_{15} + l_6 b_{16}) \tag{30}$$

3.4. Rate of Heat Transfer

$$Nu = -\left(\frac{\partial \theta}{\partial y}\right)_{y=0} = l_1 + \varepsilon e^{-nt}(l_4 b_6 - l_1 b_6) \tag{31}$$

3.5. Rate of Mass Transfer

$$Sh = -\left(\frac{\partial \phi}{\partial y}\right)_{y=0} = l_1 + \varepsilon e^{-nt}(l_4 b_6 - l_1 b_6) \tag{32}$$

4. RESULTS AND DISCUSSION

This paper, the unsteady MHD natural convective boundary layer flow of a viscous, incompressible and electrically conducting, Non-Newtonian (Jeffrey fluid) fluid over an inclined permeable moving plate in presence of heat absorption and homogenous chemical reaction, with Soret and thermal radiation subjected to the variable suction are discussed in detail through graphs from Figs. 2-13. The governing equations are having non- linear nature and have been solved by perturbation method. To assess the physical depth of the problem, the effects of various parameters such as the slip parameter h, Grashof number Gr, magnetic parameter M, permeability of porous medium K, heat source parameter Q, radiation parameter F, chemical reaction parameter K, modified Grashof number Gm, inclined angle α and Schmidt number Sc, Soret parameter Sr on velocity distribution, temperature distribution and concentration distribution are studied in Figs 1 to 13, while keeping the other parameters as constants.

Fig. 2 demonstrates the influence of angle of inclination parameter on velocity profiles. From this figure, it is observed that the velocity profiles are decreasing with increasing values of angle of inclination parameter. The effect of Hartmann number on the velocity is shown in Fig. 3. The velocity decreases with an increase in the Hartmann number. It is because that the application of transverse magnetic field will result a resistive type force (Lorentz force) similar to drag force which tends to resist the fluid flow and thus reducing its velocity. Also, the boundary layer thickness decreases with an increase in the Hartmann number.

Figs. 4 and 5 exhibits the effect of Grashof number for heat and mass transfer on the velocity profile with other parameters are fixed. The Grashof number for heat transfer signifies the relative effect of the thermal buoyancy force to the viscous hydrodynamic force in the boundary layer. As expected, it is observed that there is an enhancement in the velocity due to the rising of thermal buoyancy force. Also, as *Gr* increases, the peak values of the velocity increases rapidly near the porous plate and then decays smoothly to the free stream velocity. The modified Grashof number defines the ratio of the species buoyancy force to the viscous hydrodynamic force. As expected, the fluid velocity increases and the peak value is more distinctive due to increase in the species buoyancy force. The velocity distribution attains a distinctive maximum value in the vicinity of the plate and then decreases properly to approach the free stream value. It is noticed that the velocity increases with increasing values of the Grashof number for mass transfer.

Fig. 6 shows the effect of the permeability of the porous medium parameter on the velocity distribution. As shown, the velocity is increasing with the increasing dimensionless porous medium parameter. Physically, this result can be achieved when the holes of the porous medium may be neglected. Figure 7 depicts the velocity profiles with the variations in slip parameter (h).

It is observed that the significance of the velocity is high near the plate and thereafter it decreases and reaches to the stationery position at the other side of the plate. As expected the velocity increases with an increase in h. In Fig.8 depicts the effect of Prandtl number on the temperature field. It is observed that an increase in the Prandtl number leads to decrease in the temperature field, because, either increases of kinematic viscosity or decrease of thermal conductivity leads to increase in the value of Prandtl number. Hence temperature decreases with increasing of Prandtl number. Fig.9. tells the influence of thermal radiation conduction on the temperature. It is cleared that temperature is decrease when F is increase. Figs. 10 illustrate the influence of the heat absorption coefficient Q on the temperature profiles at $t = 1.0$, respectively. Physically speaking, the presence of heat absorption (thermal sink) effects has the tendency to reduce the fluid temperature. This causes the thermal buoyancy effects to decrease resulting in a net reduction in the fluid temperature. This behavior clearly obvious from Figs. 10, in temperature distributions decrease as Q increases. It is also observed that the thermal (temperature) boundary layer decrease as the heat absorption effects increase.

Influence of Schmidt number on concentration is shown in figure 11, from this figure it is noticed that concentration decreases with an increase in Schmidt number. Because, Schmidt number is a dimensionless number defined as the ratio of momentum diffusivity and mass diffusivity, and is used to characterize fluid flows in which there are simultaneous momentum and mass diffusion convection processes. Therefore concentration boundary layer decreases with an increase in Schmidt number. Fig. 12 display the effects of the chemical reaction parameter on the concentration profiles at t = 1. As the chemical reaction parameter K increases, the concentration decreases. This causes the concentration buoyancy effects to decrease yielding a reduction in the fluid concentration. This behavior is clearly seen in Fig 12. Figure 13 displays the influence of Soret number on concentration profile. From this figure, we may conclude that the concentration profile enhances with an increase in the Soret number. This is due to the fact that an increase in Soret number causes for concentration boundary layers.

Table – 1show numerical values of skin-friction for several of Grashof number (Gr), modified Grashof number (Gm), Magnetic parameter (M), Porosity parameter (K) and slip parameter (h). From table 1, it is observed that the skin-friction increases with an increase in Grashof number (Gr), modified Grashof number (Gm), Porosity parameter (k) where as it decreases under the influence of magnetic parameter (M), slip parameter (h), Jeffery parameter (λ) and inclined angle (α). **Table – 2** demonstrates the numerical values of Nusselt number (Nu) for different values of Prandtl number (Pr), Radiation parameter (R), Heat source parameter (Q). From table 2, we notice that the Nusselt number increases with an increase in Prandtl number, Radiation parameter and Heat source parameter. **Table – 3** displays the validation of present results with that of published results of Nagesh et al. [5] an excellent agreement is noticed in this comparison. The numerical values of Sherwood number (Sh) for the distinction values of Schmidt number (Sc), Chemical reaction parameter (K) and Soret parameter (S_r). It can be noticed from Table - 3 that the Sherwood number enhances with rising values of Schmidt number, chemical reaction parameter where as it decreases under the influence of Soret parameter.

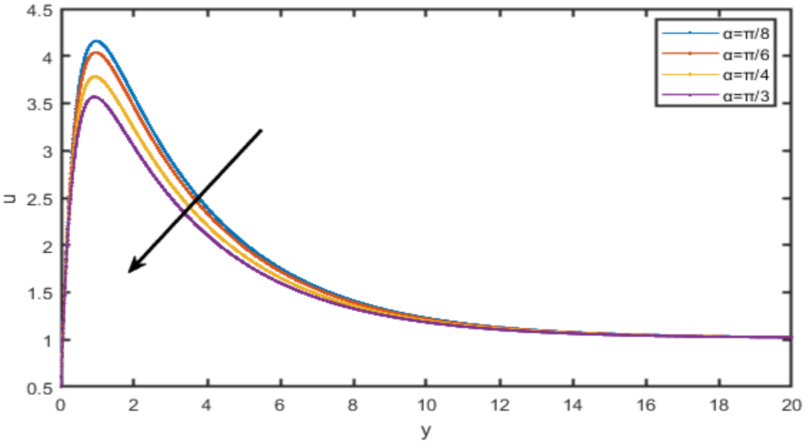

Figure 2: The Influence of Inclined angle (α) parameter on velocity profiles.

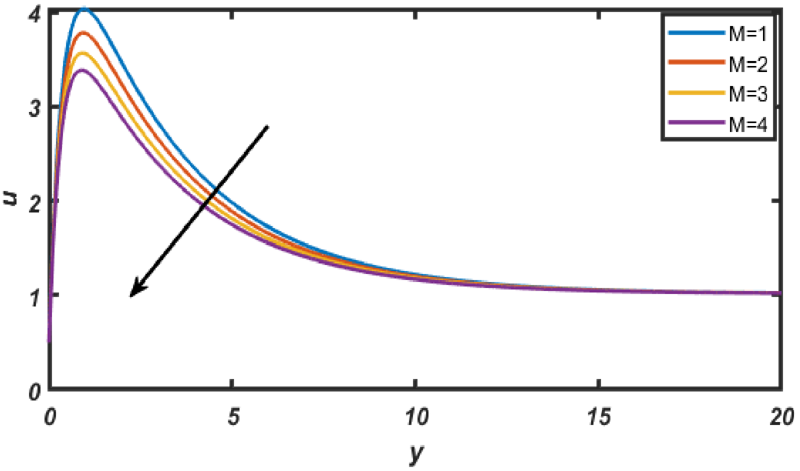

Figure 3: The Influence of Magnetic field (M) parameter on velocity profiles.

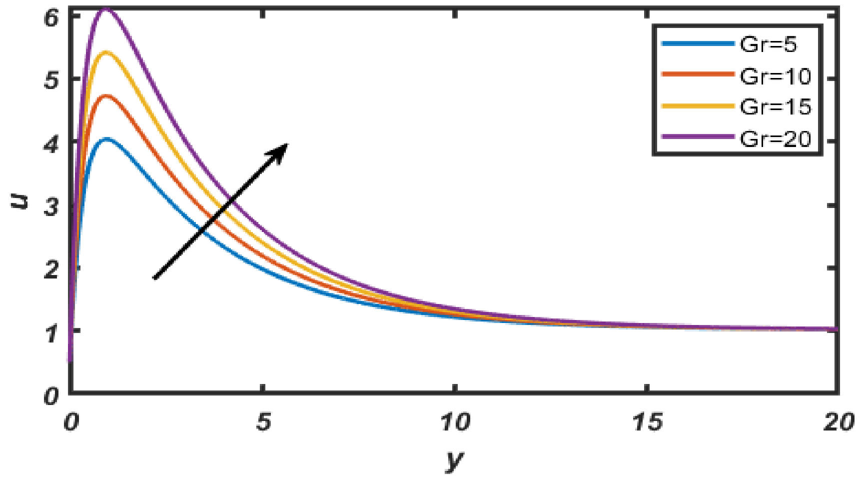

Figure 4: The Influence of thermal Grashof number (Gr) on velocity profiles.

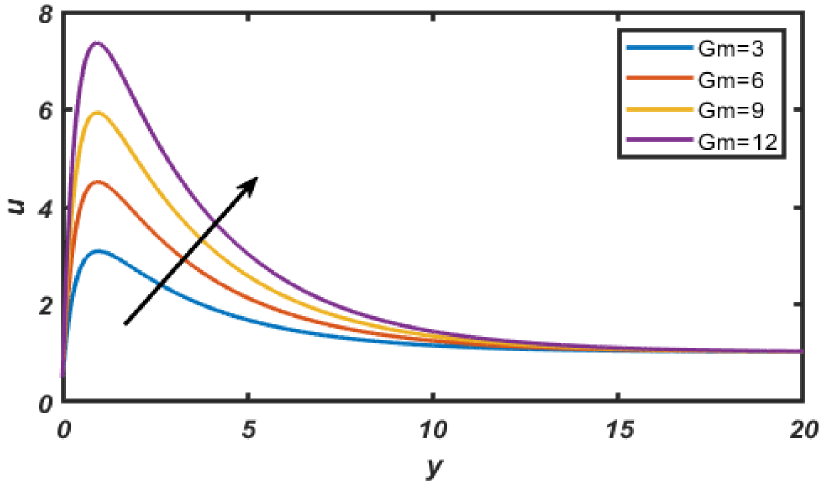

Figure 5: The Influence of mass Grashof number (Gm) on velocity profiles.

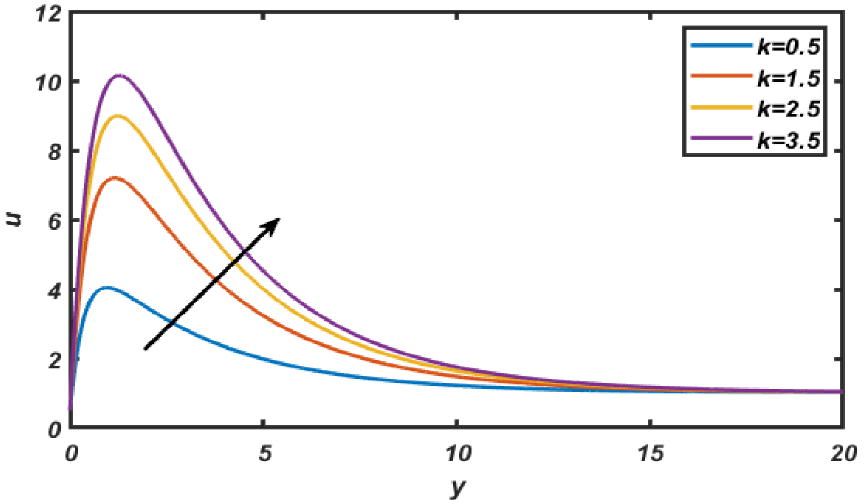

Figure 6: The Influence of Permeability of porous media (k) on velocity profiles.

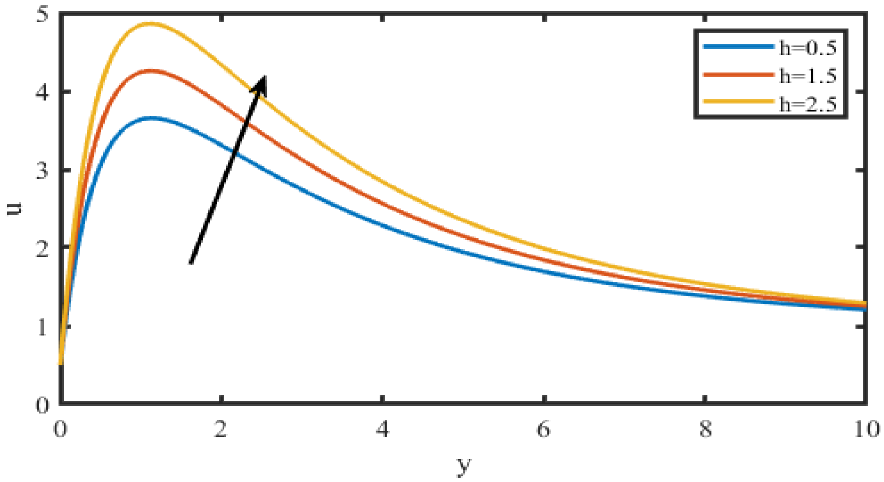

Figure 7: The Influence of slip parameter (h) on velocity profiles.

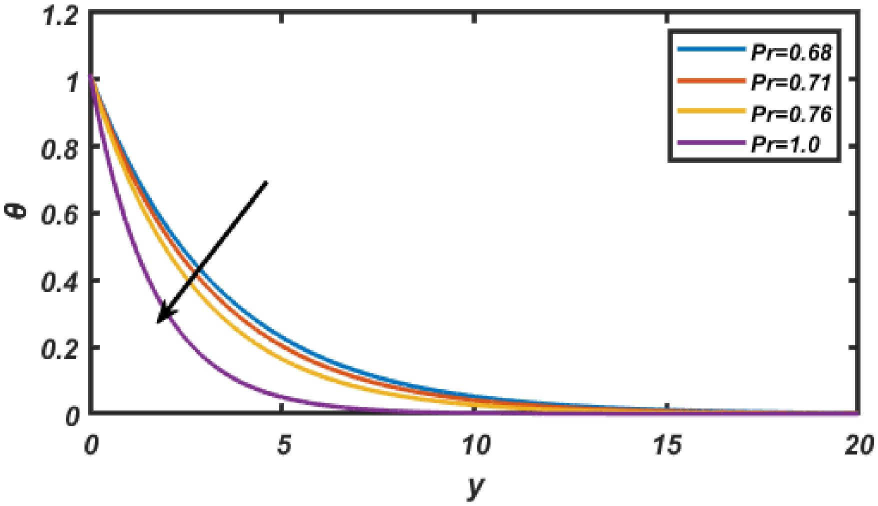

Figure 8: The influence of Prandtl number (Pr) on Temperature profiles

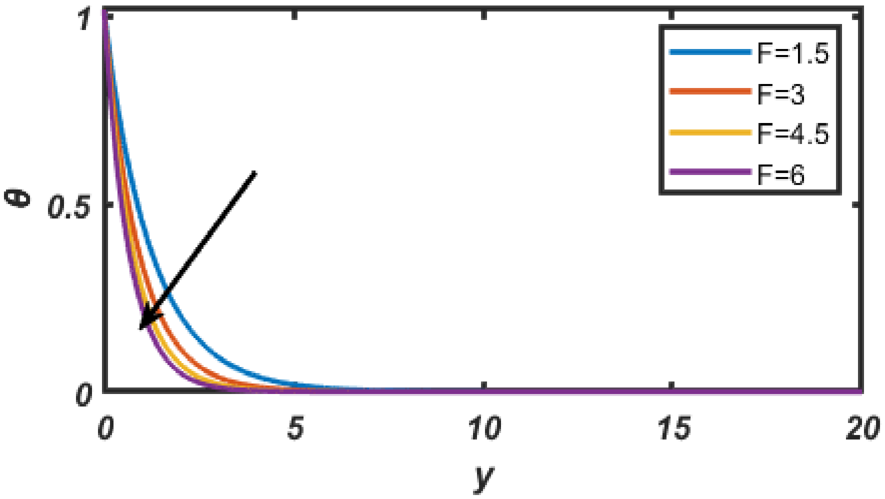

Figure 9: The influence of radiation parameter (F) on Temperature profiles

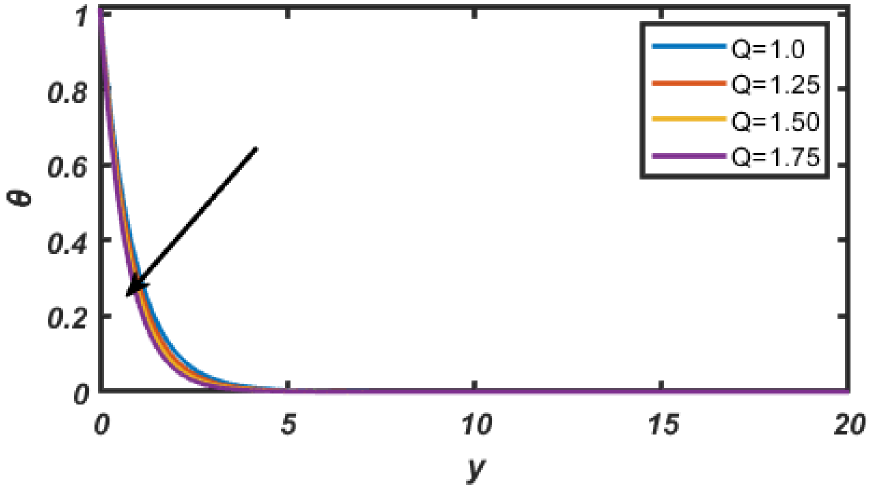

Figure 10: The influence of Heat absorption (Q) coefficient on Temperature profiles

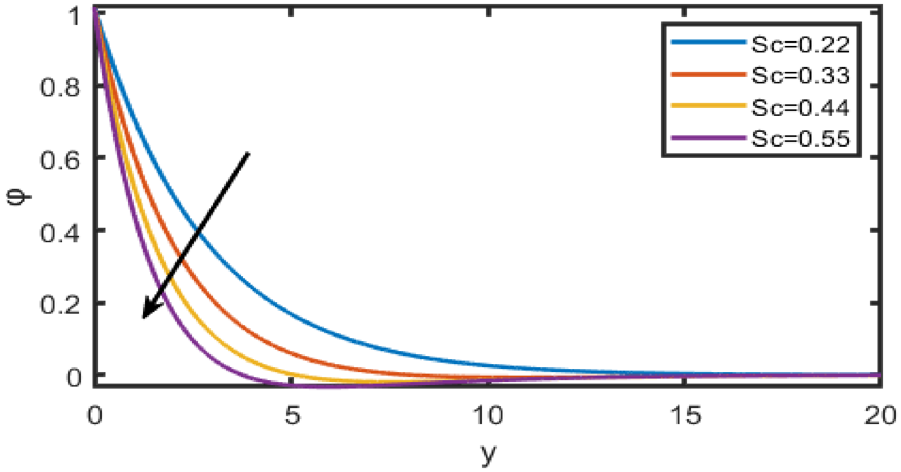

Figure 11: The influence of Schmidt number (Sc) on Concentration profiles

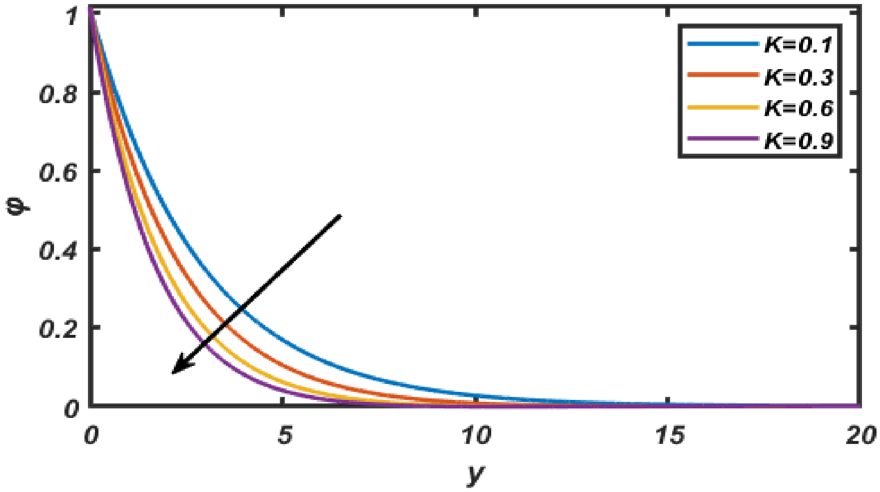

Figure 12: The influence of Chemical reaction (K) parameter on Concentration profiles

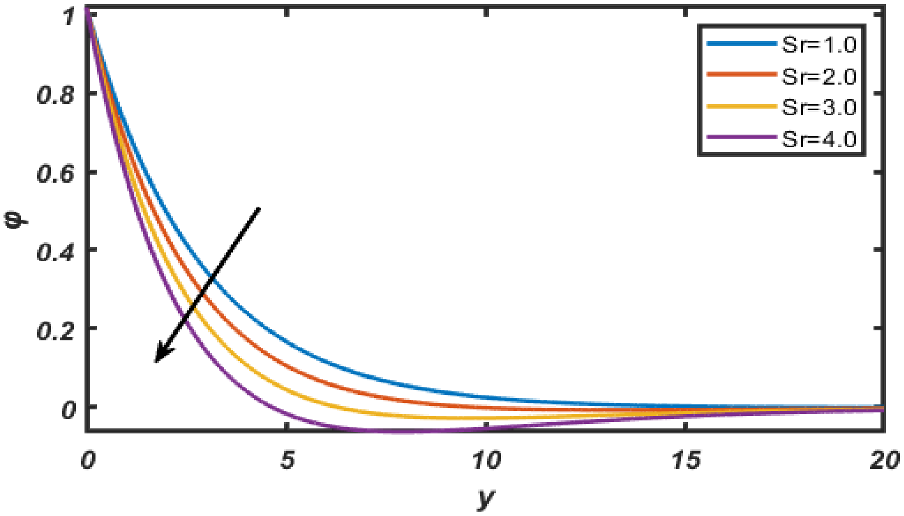

Figure 13: The influence of Soret number (Sr) on Concentration profiles

Table 1: Skin friction

Gr	Gm	M	k	h	λ	α	τ
6	3	1	0.5	0.5	1.5	π/6	1.439349
10	3	1	0.5	0.5	1.5	π/6	1.724305
14	3	1	0.5	0.5	1.5	π/6	2.00098
5	5	1	0.5	0.5	1.5	π/6	0.769754
5	12	1	0.5	0.5	1.5	π/6	2.279055
5	15	1	0.5	0.5	1.5	π/6	2.929056
5	3	2	0.5	0.5	1.5	π/6	0.439087
5	3	2.5	0.5	0.5	1.5	π/6	0.349857
5	3	3	0.5	0.5	1.5	π/6	0.279787
5	3	1	2	0.5	1.5	π/6	0.674588
5	3	1	3	0.5	1.5	π/6	0.760959
5	3	1	4	0.5	1.5	π/6	0.810409
5	3	1	0.5	1	1.5	π/6	0.760478
5	3	1	0.5	2	1.5	π/6	0.424948
5	3	1	0.5	3	1.5	π/6	0.280484
5	3	1	0.5	0.5	2	π/6	0.760383
5	3	1	0.5	0.5	2.5	π/6	0.754948
5	3	1	0.5	0.5	3	π/6	0.7490383
5	3	1	0.5	0.5	1.5	π/6	1.329034
5	3	1	0.5	0.5	1.5	π/4	1.070484
5	3	1	0.5	0.5	1.5	π/3	0.760581

Table 2: Nusselt number

Pr	F	Q	Nu
0.71			1.6369
1			2.0562
7			9.1141
	2		1.8937
	3		2.1128
	4		2.3072
		0.5	1.4864
		2	1.8937
		4	2.3072

Table 3: Sherwood number

Sc	K	S_r	Sh (Present Values)	Results of Nagesh et al. [5]
0.16			0.261923	0.2846578
0.22			0.287409	0.288263
0.60			0.358009	0.350576
	0.5		0.133124	0.1384758
	1		0.261906	0.260587
	1.5		0.360265	0.360575
		2	0.044296	0.049573
		4	-0.391295	-0.390568
		6	-0.826625	-0.829585

5. CONCLUSIONS

In this problem, the characteristics of MHD Jeffery fluid past an inclined vertical porous plate are investigated. In the analysis of the flow the following conclusions are made.

1. Fluid velocity increases with an increase in permeability parameter, Grashof number, modified Grashof number and Slip parameter where as it decreases under the influence of magnetic parameter and inclined angle.
2. Fluid temperature decreases with rising values of Prandtl number, radiation parameter, and heat absorption parameter.
3. Concentration decreases with an increase in the Schmidt number and chemical reaction Parameter and shows a reverse effect with an increase in the Soret effect.
4. As significant acceleration in the seen in skin friction for increase permeability parameter, Grashof number modified Grashof number where as it decreases under the influence of magnetic parameter, slip parameter, Jeffery parameter and inclined angle.

v. The rate of heat transfer increases with an increase Prandtl number, heat absorption parameter, and radiation parameter.
vi. The rate of mass transfer accelerated with rising values of Schmidt number, chemical reaction parameter where as it decreases under the influence of Soret parameter.

Nomenclature:

λ	Jeffrey fluid parameter	t	Dimensional time
B_0	Magnetic induction [T]	ε	Scalar constant
C	Concentration	U_0	Scale of free stream velocity
C_p	Specific heat at constant pressure	u^*,v^*	Dimensional velocity components
C_f	Skin friction coefficient	u,v	Velocity components [ms^{-1}]
D	Mass diffusion coefficient	V_0	Scale of suction velocity
D_1	Thermal diffusion coefficient	x^*,y^*	Dimensional distances along and perpendicular to the plate respectively
F	Radiation parameter	x,y	Distance along and perpendicular to the plate respectively
g	Acceleration due to gravity		**Greek Symbols**
Gr	Grashof number	μ	coefficient of viscosity
Gm	Modified Grashof number	α	Inclination angle
k	Permeability of the porous medium	β_c	Coefficient of volumetric concentration expansion
K	Chemical reaction parameter	β_T	Coefficient of volumetric thermal expansion [K^{-1}]
n	Frequency of oscillation [Hz]	ε	Scalar constant
M	Magnetic field parameter	T_∞	Free steam dimensional temperature [K]
Q	Heat absorption parameter	U_∞	Free steam dimensional velocity [m/s]
h	Slip parameter	κ	Thermal conductivity
Nu	Nusselt number	σ	Electrical conductivity
Pr	Prandtl number	ρ	Density of the fluid [kg/m]
Q_1	Heat absorption coefficient	υ	Kinematic viscosity [m^2/s]
S_r	Soret number	α	Inclined angle
Sc	Schmidt number		**Subscripts and Superscripts**
Sh	Sherwood number	P	Plate
W	Wall condition	∞	Free stream condition
Sh	Sherwood number		
T	Temperature [K]		

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