Magnetohydrodynamic Free Convective Heat and Mass Transfer Effects Over an Inclined Plate

A. Devi and L. Sivakami

Abstract: **This study examines the impact of the transfer of mass and heat characteristics on the magnetohydrodynamic natural convection travel over a slanted surface in an impermeable, electrically conductive fluid. The equations that govern can be transformed into standard differential equations through the use of nondimensional quantities, which can subsequently be solved through the ordinary perturbation method. Equations for temperature, concentration, and velocity were produced by using this method. Furthermore, MATLAB-generated graphics were used to analyse and illustrate the effects of several parameters on acceleration, concentration and temperature, including the Schmidt number, thermal Grashof, singular Grashof number and angle of inclination.**

Index Terms—**Heat and mass transfer, MHD, inclined plane.**

I. Introduction

IT is the study of the movement of electrically conducting fluids in a magnetic field that is known as magnetohydrodynamics (MHD). There is no better illustration of the MHD principle than dynamos and motors. The flow dynamics of unsteady MHD-free convection in horizontal channels have been extensively researched. The scientifically motivated applications arising from the exploration of such flows led to these studies. Magnetic drug targeting, power generation, liquid metal cooling, and MHD pumps are a few of the practical applications of MHD.

Many academics and writers have made critical contributions to the subject of the MHD inquiry. Chamkha [1] examined two viscous, incompressible, electrically conducting fluids that either produced or absorbed heat in longitudinal motion. This investigation packed a homogenous porous medium into an infinitely long, impermeable parallel-plate channel. To investigate the simultaneous transmission of heat and mass, Ganesan and Palani [2] numerically explored transient natural convection flows that originated from a tilted plate. We applied the Crank-Nicolson implicit minimal difference approach to more thoroughly assess their findings. Sivakami et al. [3] explored the effects of mass and heat transfer on the irregular, unrestrained turbulent flow of insoluble fluids in a horizontal channel, accounting for the effects of a magnetic field and chemical processes. Angel et al. [4] explored how heat and mass transfer could be combined through free convection adjacent to an inclined flat plate.

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Antony Gnana Aravind et al. [5] studied the effects of a rotating fluid on a vibrating downward-pointing surface, taking into account variations in both temperature and mass dispersal. Malashetty et al. [6] examined the motion of two fluids in an inclined channel alongside porosity and fluid layers under a permeable stretched sheet. Shit and Haldar [7] investigated the effects of electromagnetic radiation, heat exchange, and the Hall effect on magnetohydrodynamic (MHD) dynamics in an angled channel. Daniel [8] addressed how it affected the atmospheric pressure gradient and deliberated on both convection and heat flow in a non-mixable fluid.

Punnam Chandar Bitla and Fekadu Yemataw Sitotaw [9] examined the impact of an angled magnetic flux and slip circumstances on the flow of insoluble fluid in permeable passages. Hasan Nihal Zaidi and Naseem Ahmad [10] conducted a study on the circulation movement of two inseparable fluids in an inclination way, considering the existence of condensed warmth through emission or digestion. Sneha and Yadav [11] investigated the movement of non-mixing fluids, such as pair stress fluid and Jeffrey fluid, across porosity tubes. Their work deviated from the traditional no-slip boundary criteria by including slip boundaries and analyzing the impact of a directed field of magnets.

Malashetty and Umavathi [12] examined heat transfer an inclined plane with two-phase magnetohydrodynamic flow. Agarwal and Kumar [13] investigated pulsating magnetohydrodynamic (MHD) flow in an incompressible viscous porous medium bounded by horizontal plates of two immiscible fluids, one conducting the heat and the other non-conducting. Ramana Murthy and Srinivas [14] investigated the impact of slip barriers and a voltage field on the movement of similar fluids in a sloping porous surface. They applied the Stokes model to a rectangular cage. Beckermann et al. [15] examined the process of heat exchange and transpiration flow in a fluid-filled and porous stratum. Mankinde and Mhone [16] investigated the interplay between optical transfer of energy and a longitudinal magnetic field in a saturated porous material. They focused on the dynamic flow of an optically thin fluid in a channel subjected to varying heating ranges.

Gbadeyan and Dada [17] investigated the impact of radiation and Hall electrical currents on the outermost layer of a periodic structure and a pulling surface that varied in stickiness. Mateen [18] examined the thermal conduction and magnetohydrodynamic flows of two non-mixing fluids in a horizontal conduit. Umavathi et al. [19] conducted a study on heat transmission and circulation of turbulent magnetohydrodynamic fluid in a parallel channel. Chen [20] employed the sixth-order Runge-Kutta approach in conjunction with the Nachtsheim-Swigert shot repetition technique to investigate the movement of mass and heat in magnetohydrodynamic (MHD) flow with fluctuating concentration and wall temperature. Vafai and Tien [21] investigated the impact of barriers and inertia on the transport of heat and flow in porous surfaces. While Moutsoglou and Chen [22] analyzed the buoyancy effects on inclined, continuous, moving sheets. In their study, Titilayo Morenike Agbaje et al. [23] looked into how MHD air flow behaves when it moves in one direction from a flat plate that lets air pass through it. They used a good broad spectrum clustering method to do this. The study examined numerous elements, including heat radiation, chemical processes, Soret and Dufour effects, and consistent surface temperature. In his work, Azis [24] tackled unstable state issues for many kinds of governing equations.

This paper examines the consequences of magnetohydrodynamic unconstrained convective transfer of mass and heat towards an inclined plate, building on the previously mentioned study.

II. THE PROBLEM FORMULATION

Assume that inflexible viscous substance that is submerged in a clear liquid and streams gradually across a slanted plate at an acute angle Φ. The plate ensures a predetermined mass flux Tw while maintaining an equilibrium wall temperature Tw, which is greater than the surrounding surface temperature T. On a slanted plate that is semi-infinite, the flow proceeds along the x-axis and the y-axis are opposed to it. The above investigation implies that all fluid factors are constant and that the magnetic field that is generated is insignificant. Using boundaries as constraints and Boussinesq's estimation, construct the fundamental equations for acceleration, mass, energy, and tension for this steady flow.

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

$$\rho\left(\frac{\partial U'}{\partial t'} + V'\frac{\partial U'}{\partial y'}\right) = \mu\frac{\partial^2 U'}{\partial y'^2} - \frac{\partial P'}{\partial x'} - \sigma B_0^2 U' + \rho g\beta_f(T - T'_w)\cos\Phi + \rho g\beta_c^*(C - C'_w)\cos\Phi \tag{2}$$

$$\rho C_p\left(\frac{\partial T'}{\partial t'} + V'\frac{\partial T'}{\partial y'}\right) = k\frac{\partial^2 T'}{\partial y'^2} - \frac{\partial q_r}{\partial y} \tag{3}$$

$$\frac{\partial C'}{\partial t'} + V'\frac{\partial C'}{\partial y'} = D\frac{\partial^2 C'}{\partial y'^2} \tag{4}$$

Consequently, the liquid's outer boundary states are listed below: $t \le 0;\ u' = 0,\ T' = T'_{w1},\ C' = C'_{w1}$ for all y

$$t' > 0\ : \begin{cases} u' = U_0,\ T' = T'_{w1} + (T - T_{w1})At', \\ C' = C'_{w1} + (C - C_{w1})AT' \text{ at } y = 0, \\ u' = 0,\ T' \to T'_{w1},\ C' \to C'_{w1} \text{ as } y \to \infty \end{cases} \tag{5}$$

In accordance with the continuity rule (1), V' and y' are separate from one another and may only be a function duration. Thus, we are able to compose sentences.

$$V' = V_0(1 + \varepsilon A e^{i\omega t}) \tag{6}$$

Let $V_1' = V'$. Here ε is the smallest positive quantity and it has a value $\varepsilon A \ll 1$. A constant, non-zero average speed is assumed here to be the transpiration velocity V'. Dimensionless quantities can be calculated as follows:

$$U = \frac{U'}{u},\ y = \frac{y'}{h},\ t = \frac{t'v}{h^2},\ V = \frac{h}{v_1}V' = \frac{V}{V_0},\ P = \frac{-h^2}{\mu u}\left(\frac{\partial P'}{\partial x'}\right),$$

$$\theta = \frac{T' - T'_\infty}{T'_w - T'_\infty},\ Pr = \frac{\mu c_p}{k},\ K^2 = \frac{h^2}{K'},\ Sc = \frac{v}{D},\ C = \frac{C' - C'_\infty}{C'_w - C'_\infty}$$

$$M^2 = \frac{\sigma h^2 B_0^2}{\mu},\ F = \frac{4I'h^2}{k},\ \frac{\partial q_r}{\partial y} = 4(T'_w - T'_\infty)I',$$

$$Gc = \frac{\rho g h^2 \beta_c^*(C'_w - C'_\infty)}{\mu u},\ Gr = \frac{\rho g h^2 \beta_f(T'_w - T'_\infty)}{\mu u}.$$

Equation (2), (3), (4) becomes

$$\frac{\partial U}{\partial t} + (1 + \varepsilon e^{i\omega t})\frac{\partial U}{\partial y} = \frac{\partial^2 U}{\partial y^2} + P - M^2 U + Gr\theta\cos\Phi + Gc\, C\cos\Phi \tag{7}$$

$$\frac{\partial \theta}{\partial t} + (1 + \varepsilon e^{i\omega t})\frac{\partial \theta}{\partial y} = \frac{1}{Pr}\frac{\partial^2 \theta}{\partial y^2} - \frac{F\theta}{Pr} \tag{8}$$

$$\frac{\partial C}{\partial t} + (1 + \varepsilon e^{i\omega t})\frac{\partial C}{\partial y} = \frac{1}{Sc}\frac{\partial^2 C}{\partial y^2} \tag{9}$$

The boundary values in dimensionless forms are given:

$$\left.\begin{array}{l} u_0 = 1,\ \theta_0 = t,\ C_0 = t,\ \text{at } y = 0 \\ u_1 = 0,\ \theta_1 = 0,\ C_1 = 0,\ \text{at } y \to \infty \end{array}\right\} \tag{10}$$

III. METHODOLOGY / SOLUTION

Using our boundary restrictions (10), we can solve the aforementioned equations (7-9) by expanding $U_{01}(y,t)$, …. as a power of the series in the perturbative parameter ε. This suggests that is peak to trough amplitude is restricted (ϵ≪1),

$$U_{01}(y,t) = U_{10}(y) + \varepsilon e^{i\omega t}U_{11}(y)$$

$$\theta_{01}(y,t) = \theta_{10}(y) + \varepsilon e^{i\omega t}\theta_{11}(y)$$

$$C_{01}(y,t) = C_{10}(y) + \varepsilon e^{i\omega t}C_{11}(y)$$

Non-Periodic Terms:

$$\frac{\partial^2 U_{10}}{\partial y^2} - \frac{\partial U_{10}}{\partial y} - M^2 U_{10} = -P - Gr\theta_{10}\cos\Phi - GcC_{10}\cos\Phi \tag{11}$$

$$\frac{\partial^2 \theta_{10}}{\partial y^2} - Pr\frac{\partial \theta_{10}}{\partial y} - F\theta_{10} = 0 \tag{12}$$

$$\frac{\partial^2 C_{10}}{\partial y^2} - Sc\frac{\partial C_{10}}{\partial y} = 0 \tag{13}$$

Periodic terms:

$$\frac{\partial^2 U_{11}}{\partial y^2} - \frac{\partial U_{11}}{\partial y} - (M^2 + i\omega)U_{11} = \frac{\partial U_{10}}{\partial y} - Gr\theta_{11}\cos\Phi - GcC_{11}\cos\Phi \tag{14}$$

$$\frac{\partial^2 \theta_{11}}{\partial y^2} - Pr\frac{\partial \theta_{11}}{\partial y} - (F + i\omega Pr)\theta_{11} = Pr\frac{\partial \theta_{10}}{\partial y} \tag{15}$$

$$\frac{\partial^2 C_{11}}{\partial y^2} - Sc\frac{\partial C_{11}}{\partial y} - i\omega Sc C_{11} = Sc\frac{\partial C_{10}}{\partial y} \tag{16}$$

Even though equations (11) and (16) have constant coefficients, they can still be classified as normal linear differential equations. As a result, the boundary conditions are,

$$\left.\begin{array}{c} U_{10} = 01,\ U_{11} = 0,\ \theta_{10} = te^{-\omega t},\ \theta_{11} = 0,\ C_{10} = te^{-\omega t}, \\ C_{11} = 00 \text{ at } y = 00 \\ U_{10} = 00,\ U_{11} = 0,\ \theta_{10} = 0,\ \theta_{11} = 0,\ C_{10} = 00,\ C_{11} = 00 \\ \text{at } y \to \infty \end{array}\right\} \tag{17}$$

According to the boundary conditions (17), the analytical solutions of differential equations (11) to (16) are as follows:

$$U_{10}(y) = C_5 e^{m_{05}y} + C_6 e^{m_{06}y} + K_1 + K_2 e^{m_{01}y} + K_3 e^{m_{02}y} + K_4 e^{m_{03}y} + K_5 e^{m_{04}y} \tag{18}$$

$$\theta_{10}(y) = C_1 e^{m_1 y} + C_2 e^{m_2 y} \tag{19}$$

$$C_{10}(y) = C_3 e^{m_3 y} + C_4 e^{m_4 y} \tag{20}$$

$$U_{11}(y) = C_{11}e^{m_{11}y} + C_{12}e^{m_{12}y} + K_{10}e^{m_1 y} + K_{11}e^{m_2 y} + K_{12}e^{m_{03}y} + K_{13}e^{m_{04}y} + K_{14}e^{m_{05}y} + K_{15}e^{m_{06}y} + K_{16}e^{m_{07}y} + K_{17}e^{m_{08}y} + K_{18}e^{m_{09}y} \tag{21}$$

$$\theta_{11}(y) = C_7 e^{m_7 y} + C_8 e^{m_8 y} + K_6 e^{m_1 y} + K_7 e^{m_2 y} \tag{22}$$

$$C_{11}(y) = C_9 e^{m_9 y} + C_{10}e^{m_{10}y} + K_8 e^{m_3 y} + K_9 e^{m_4 y} \tag{23}$$

Where, $V_1 = F + i\omega Pr$, $V_2 = i\omega Sc$, $V_3 = M^2 + i\omega$, $m_{01} = \frac{Pr + \sqrt{Pr^2 + 4F}}{2}$, $m_{02} = \frac{Pr - \sqrt{Pr^2 + 4F}}{2}$, $m_{03} = 0$, $m_{04} = Sc$, $m_{05} = \frac{1 + \sqrt{1 + 4M^2}}{2}$, $m_{06} = \frac{1 - \sqrt{1 + 4M^2}}{2}$, $m_{07} = \frac{Pr + \sqrt{Pr^2 + 4V_1}}{2}$,

$m_{08} = \frac{Pr-\sqrt{Pr^2+4V_1}}{2}$, $m_{09} = \frac{Sc+\sqrt{Sc^2+4V_2}}{2}$, $m_{10} = \frac{Sc-\sqrt{Sc^2+4V_3}}{2}$, $m_{11} = \frac{1+\sqrt{1+4V_3}}{2}$, $m_{12} = \frac{1-\sqrt{1+4V_3}}{2}$, $r_{01} = e^{-m_2}$, $r_{02} = 1 - e^{(m_1-m_2)}$, $r_{03} = e^{-m_4}$, $r_4 = 1 - e^{(m_3-m_4)}$, $r_{05} = m_4 e^{-m_4}$, $r_6 = m_4 e^{(m_3-m_4)} - m_3$, $r_7 = m_2 e^{-m_2}$, $r_8 = m_2 e^{(m_1-m_2)} - m_1$, $r_9 = m_6 e^{(m_5-m_6)} - m_5$, $r_{10} = m_{12} e^{(m_{11}-m_{12})} - m_{11}$, $r_{11} = m_8 e^{(m_7-m_8)} - m_7$, $r_{12} = m_{10} e^{(m_9-m_{10})} - m_9$, $K_1 = \frac{P}{M^2}$, $K_2 = -\frac{GcC_1 \cos\Phi}{m_1^2-m_1-M^2}$, $K_3 = -\frac{GrC_2 \cos\Phi}{m_2^2-m_2-M^2}$, $K_4 = -\frac{GcC_3 \cos\Phi}{m_3^2-m_3-M^2}$, $K_5 = -\frac{GcC_4 \cos\Phi}{m_4^2-m_4-M^2}$, $K_6 = \frac{PrC_1 m_1}{m_1^2-Prm_1-V_1}$, $K_7 = \frac{PrC_2 m_2}{m_2^2-Prm_2-V_1}$, $K_8 = \frac{ScC_3 m_3}{m_3^2-Scm_3-V_2}$, $K_9 = \frac{ScC_4 m_4}{m_4^2-Scm_4-V_2}$, $K_{10} = \frac{K_2 m_1 - GcK_6}{m_1^2-m_1-V_3}$, $K_{11} = \frac{K_3 m_2 - GrK_7}{m_2^2-m_2-V_3}$, $K_{12} = \frac{K_4 m_3 - GcK_8}{m_3^2-m_3-V_3}$, $K_{13} = \frac{K_5 m_4 - GcK_9}{m_4^2-m_4-V_3}$, $K_{14} = \frac{C_5 m_5}{m_5^2-m_5-V_3}$, $K_{15} = \frac{C_6 m_6}{m_6^2-m_6-V_3}$, $K_{16} = \frac{N_1 C_7}{m_7^2-m_7-V_3}$, $K_{17} = \frac{N_1 C_8}{m_8^2-m_8-V_3}$, $K_{18} = \frac{N_2 C_9}{m_9^2-m_9-V_3}$, $K_{19} = \frac{N_2 C_{10}}{m_{10}^2-m_{10}-V_3}$, $N_1 = -Gr\cos\Phi$, $N_2 = -Gc\cos\Phi$, $A_1 = K_2 m_1 e^{m_1} + K_3 m_2 e^{m_2} + K_4 m_3 e^{m_3} + K_5 m_4 e^{m_4}$, $A_2 = K_1 + K_2 e^{m_1} + K_3 e^{m_2} + K_4 e^{m_3} + K_5 e^{m_4}$, $A_3 = K_2 m_1 + K_3 m_2 + K_4 m_3 + K_5 m_4$, $A_6 = 1 - (K_6 e^{m_1} + K_7 e^{m_2})$, $A_7 = K_6 m_1 + K_7 m_2$, $A_9 = K_8 m_3 + K_9 m_4$, $A_8 = 1 - (K_8 e^{m_3} + K_9 e^{m_4})$, $C_1 = \frac{r_7}{r_8}$,

$$A_4 = K_{10}e^{m_{01}} + K_{11}e^{m_{02}} + K_{12}e^{m_{03}} + K_{13}e^{m_{04}} + K_{14}e^{m_{05}} + K_{15}e^{m_{06}} + K_{16}e^{m_{07}} + K_{17}e^{m_{08}} + K_{18}e^{m_{09}} + K_{19}e^{m_{10}}$$

$$A_5 = K_{10}m_{01} + K_{11}m_{02} + K_{12}m_{03} + K_{13}m_{04} + K_{14}m_{05} + K_{15}m_{06} + K_{16}m_{07} + K_{17}m_{08} + K_{18}m_{09} + K_{19}m_{10}$$

$Q_1 = A_3 - A_2 m_6 e^{-m_6}$, $Q_2 = A_5 - A_4 m_{12} e^{-m_{12}}$, $C_3 = \frac{r_5}{r_6}$, $Q_3 = A_7 + A_6 m_8 e^{-m_8}$, $Q_4 = A_9 + A_8 m_{10} e^{-m_{10}}$, $C_5 = \frac{Q_1}{r_9}$, $C_4 = e^{-m_4} - C_3 e^{(m_3-m_4)}$, $C_2 = e^{-m_2} - C_1 e^{(m_1-m_2)}$, $C_7 = \frac{Q_3}{r_{11}}$, $C_9 = \frac{Q_4}{r_{12}}$, $C_6 = -A_2 e^{-m_6} - C_5 e^{(m_5-m_6)}$, $C_8 = A_6 e^{-m_8} - C_7 e^{(m_7-m_8)}$, $C_{11} = \frac{Q_2}{r_{10}}$, $C_{10} = A_8 e^{-m_{10}} - C_9 e^{(m_9-m_{10})}$, $C_{12} = -A_1 e^{-m_{12}} - C_{11} e^{(m_{11}-m_{12})}$.

IV. RESULTS AND DISCUSSIONS

This paper examines the movement of a viscous, impermeable, electrically conductive fluid interacting with the semi-infinite slanted plate. By modifying variables like the Grashof amount (Gr = 4), concentration Grashof value (Gc = 4), Prandtl quantity (Pr = 0.68), Schmidt volume (Sc = 0.78), Froude number (F = 03), K = 05, P = 01, M = 01, ω = 10, and the cosine of the inclination angle (cos Φ = 40), it investigates the concentration, velocity, and temperature identities. MATLAB was used to gather and analyse the data.

Fig.1 shows the velocity profile for the thermal Grashof number which are expressed in different ways. Thermal Grashof number Gr, will quantify thermal buoyancy forces, which are relative to viscous hydrodynamic forces within the boundary layers. Due to the increased thermal buoyancy force, we observe an increase in velocity. Furthermore, with higher Gr values, the peak velocity within the region rapidly increases. The velocity profiles for solutal Grashof numbers are expressed in different ways. In Fig.2 the Grashof number (Gc) governs the relation between a buoyancy and viscous hydrodynamic force. When the buoyancy force of a species increases, fluid velocity increase, and its peak value becomes more distinct. Before gradually decreasing to the value of the free stream, the velocity distribution reaches its peak near the plate. Notably, the velocity demonstrates a direct correlation with rising solutal Grashof number values.

Fig.3 shows how surface inclination affects velocity. With increasing angle of inclination (Φ), velocity increases. As the plate moves vertically, the speed reaches its highest point. Compared to an inclined surface, fluid velocity is higher on a vertical one. During an inclined plate, gravity (cos(Φ)) reduces buoyancy effects, which shows the resulting difference in the fluid flow. Fig.4 illustrates the rise in a measure of magnetic attraction (M) across different values, demonstrating a corresponding decrease in the velocity field for each M value. This effect is observed due to the introduction of a transverse magnetic field into an electrically conducting fluid, where the Lorentz force induces the magnetic field. Fig.5 depicts the influence of the Prandtl number on the velocity field, highlighting how momentum diffusivity progressively outweighs thermal diffusivity.

Fig.6 and Fig.7 exemplify precisely how the exposure attribute plus the pressure disparity harm the rate at which the flow proceeds. It transpires that, equipped with a wider rate edge phase, the rate declines and the viscous fraction hikes. Moreover, as the powerful electromagnetic force gains a stronger hold beyond its motion, the subject, as shown in Fig.7 is glaring.Fig.8 illustrates the positive impact of the Schmidt value on the particle concentration characteristic, which diminishes as Sc increases. The buoyancy value suggests that the Schmidt number is the explanation for such actions. The depicted reductions in speed and quantity result from a combined drop in depth in both the inertia and concentration boundaries. Because a spike in Sc produces an erosion in particle diffusivity (D), the concentration boundary layer retreats as Sc declines. Therefore, higher species density correlates with higher Sc beliefs, while lower species density correlates with lower Sc rates.

Fig.9 and Fig.10 illustrate the significance of the radiation parameter F and the Prandtl number Pr in the temperature description, which aligns with the narrowing of the temperature range. Pr causes this phenomenon by increasing the dimension on the outer wall of heat. The temperature profiles' radiation parameter (F) exhibits a slight reduction in correlation with the thermal conductivity ratio, which rises with radiation parameter extents.

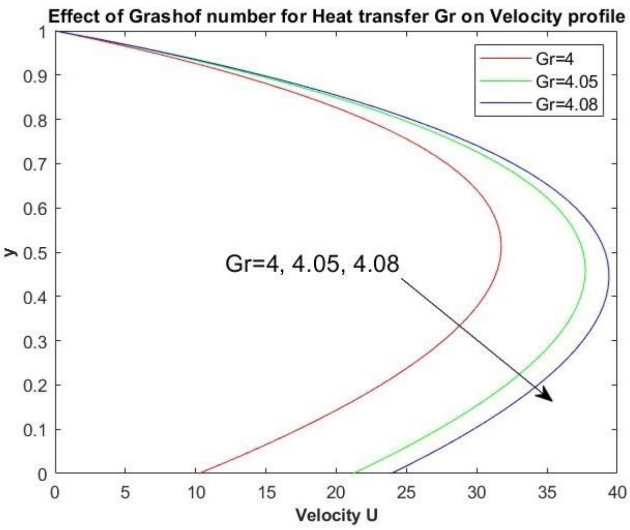

Fig 1: The Grashof number (Gr) and their impact on Velocity.

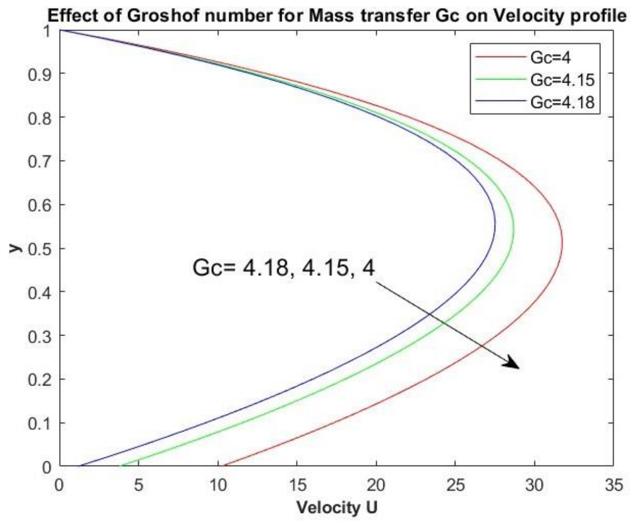

Fig 2. The Grashof number (Gc) and their impact on Velocity.

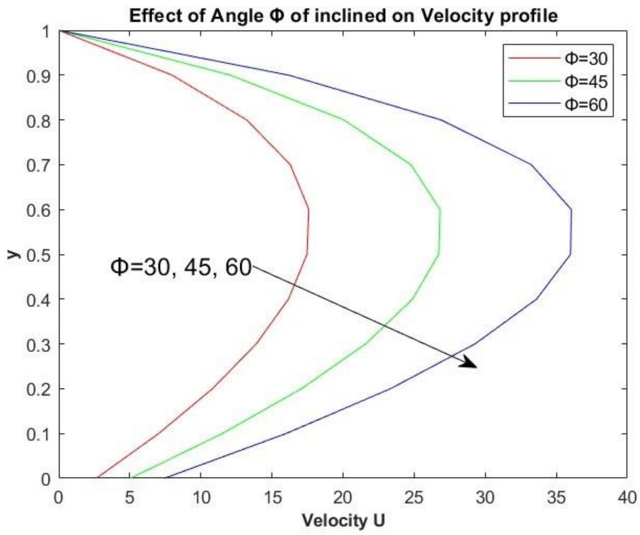

Fig 3. The angle (Φ) and their impact on Velocity profile.

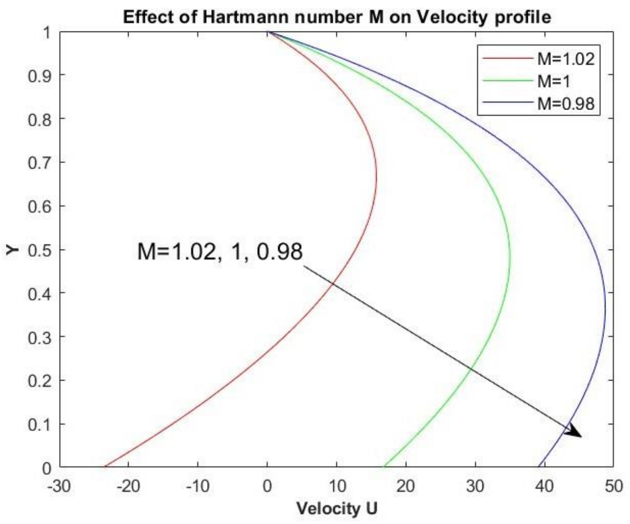

Fig 4. The Hartmann number (M) and their impact on the Velocity profile.

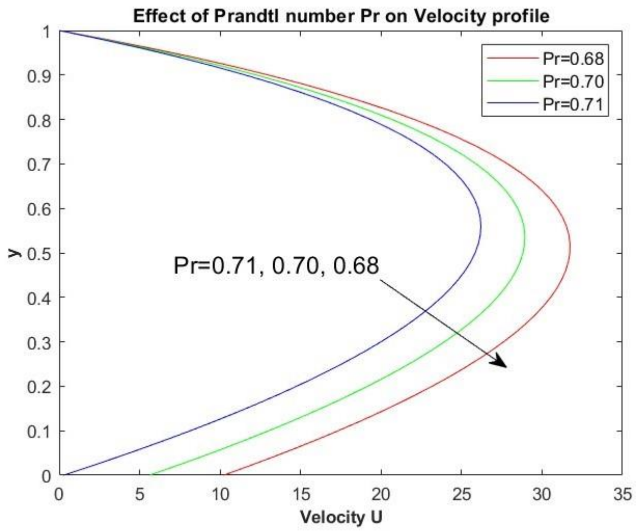

Fig 5. The Prandtl (Pr) and their impact on Velocity profile.

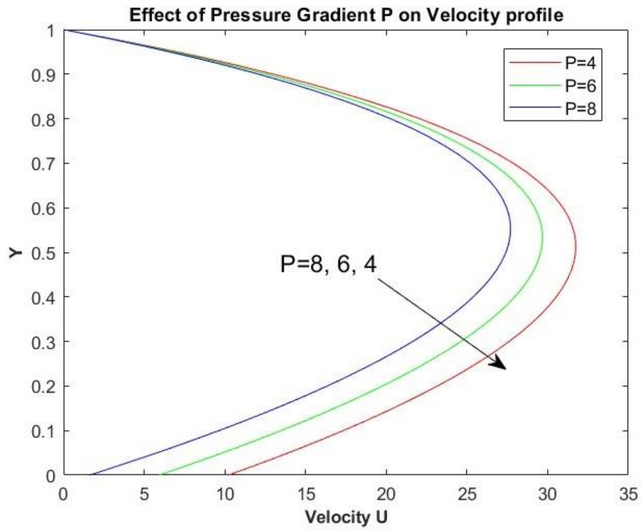

Fig 6. Impact of the Pressure Gradient (P) on the Velocity.

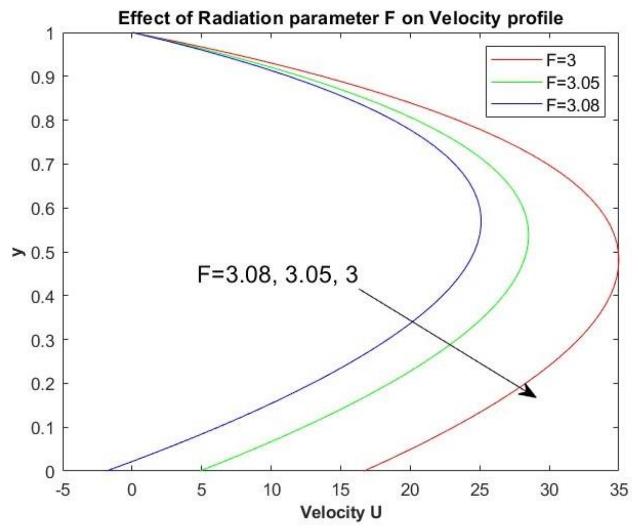

Fig 7. The Radiation parameter (F) and their impact of the Velocity profile.

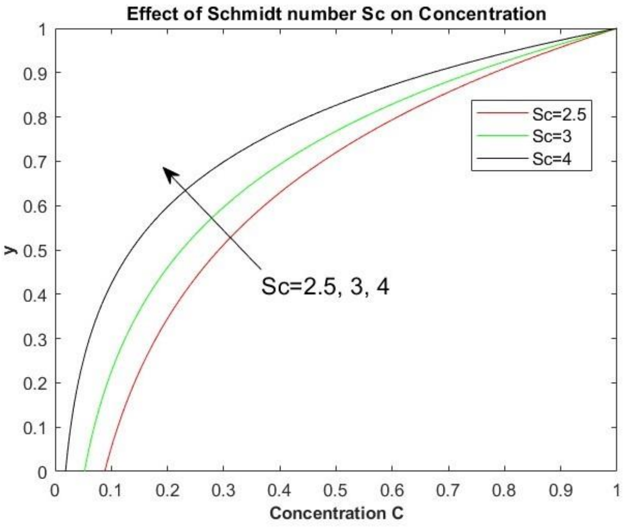

Fig 8. Schmidt number (Sc) and its effect on concentration.

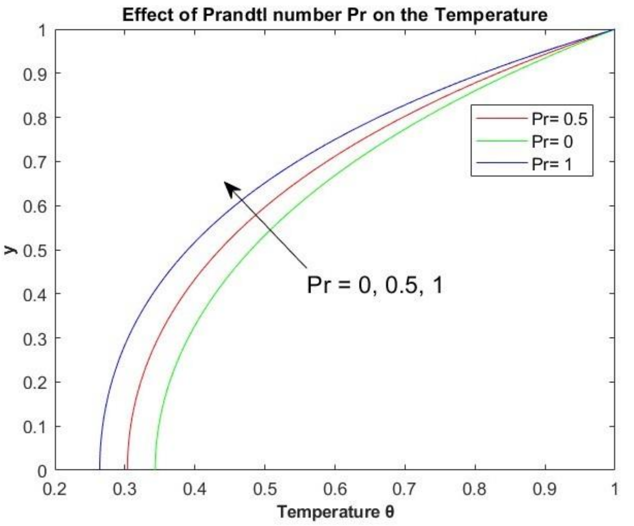

Fig 9. Prandtl number (Pr) and its effects on Temperature.

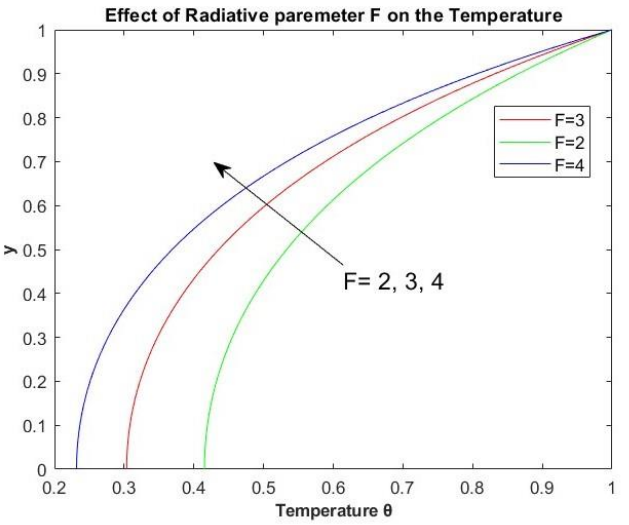

Fig 10. Radiative parameter (F) and its effects on Temperature profile.

V. CONCLUSION

We explored the theory of MHD unrestricted turbulent insoluble circulation of fluid comprising bulk and heat conveyance inside an elevated track.

1. The elevation ratio, viscous proportion, Grashof quantity, direction of orientation, and heating factor all enhance the pattern's motion.
2. As Sc moves forward, intent rises to the top.
3. The thermodynamic interview increases with fluctuations in peak proportions, thermal efficiency, Grashof quantity, and heat index creation.

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