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Research Article

MHD Jeffrey Hybrid NANOFLUID Flow with Vanadium Pentoxide (V_2O_5) and Thermal Radiation Squeezed Between Two Parallel Plates

A.G. Madaki[1*], A. A. Hussaini[2], Philemon Lare[3]

[1,2,3]Department of Mathematical Science Faculty of Sciences, Abubakar Tafawa Balewa University, Bauchi, Nigeria

**Corresponding Author: abdulmdk119@hotmail.com*

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Abstract— this work exposes the properties of the transmission of heat and mass in Jefferies nanofluids that are hybrid over the squeezing plates that travel across a porous material, as well as the nature of magnetohydrodynamics (MHD) fluid flow. The influence of thermal radiation parameters together with other pertinent parameters are studied. Suitable similarity transformation is applied to the system of dimensionless equations to discretize them. Vanadium Pentoxide (V_2O_5) dispersions are deliberated in the base fluid. Validation of this research is achieved by relating to published results. Graphs and tables discuss the momentum, and temperature, with Nusselt number and concentration profiles. The graphical results show that the temperature profile elevates with $S < 0$, $S > 0$, Ha, Ec and Rd, while it drops for De and λ. The Nusselt number profile had increased with an increase in Pr, while it decreased with an increase in the thermal radiation parameter Rd. While Ha and λ increase fluid flow concentration while lowering the mass exchange rate, they have a major negative effect on the thermal radiation parameter Rd.

Keywords— Jeffrey hybrid nanofluid, MHD, Squeeze flow, Thermal radiation, Chemical reaction

1. Introduction

Convective heat transfer in nanofluids has drawn a lot of attention in the last few years. Choi [1] first used the term "nanofluid" to refer to a liquid solution that contains tiny particles (diameter less than 50 nm). According to experimental investigations (e.g., Madaki et al., [2] and [3]), the base liquid's thermal conductivity can be improved by 10-50%, with a notable improvement in the convective heat transfer coefficient, even with a modest volumetric proportion of nanoparticles (typically less than 5%). The volatile flow in two dimensions of a viscous magnetohydrodynamic MHD fluid across two parallel inconceivable plates was investigated and analysed by Akbar et al. [4]. A review of the literature reveals that the squeeze Jeffrey flow across two parallel plates is the subject of most studies. Squeezing flow is the term used to describe the constriction of fluid across two separate plates that results in the fluid beginning to flow. Because it is used in the geometric model of lubricant flow in pneumatic elevators, moulding with injections, and bearings as well, it has been researched by several scientists, such as Madaki et al. [5], [6], [7], Hussaini et al. [8], [9]. Wang [10] discovered an entirely novel similarities transformation for Navier-Stokes into ODEs viscous fluid of squeezing flow. Bujurke et al. [11] further examined a logical clarification. Rashidi et al. [12], along with Khan et al. [13]. Scientists are quite interested in Jeffrey fluid because it exhibits both relaxation and retardation characteristics. How the fluid behaves in response to applied shear stress. Because it can change from a shear thinning flow to a Newtonian fluid when a high force is applied to the fluid, it is categorized as such. Noor et al. [14]. Matinfar et al. [15] went into great detail about the impact of thermal radiation on squeezing, Jeffery fluid fluxes. The impact of thermal radiation and heat generation/absorption on the squeezing of unstable cu as well as TiO_2-nanofluid was investigated quantitatively as well as computationally by Madaki et al. [16]. Mamatha et al. [17] investigated the effect of electromagnetic radiation on non-steady free convection magnetohydrodynamic flows of Brinkman-type systems over a porous media that is heated by Newtonian radiation. Thermal radiation's influence on squeezing flow fluid from Casson between parallel plates was reported by Khan et al. [18]. Makinde et al. [19] examined the effects of Brownian motion and thermophoresis on MHD bioconvection of nanofluid through a quartic chemical process along with the nonlinear thermal radiation beyond an upper horizontal surface of a paraboloid of rotation. The influence of an integrated electromagnetic field on radiant bioconvection flow via a plate that is vertical having thermophoresis along with Brownian motion was studied by Avinash et al. [20]. The impacts of suspended nanoparticles and non-linear thermal radiation on the convection and heat transfer boundary layer flow of nanofluids on a heated vertical sheet were examined by Mahanthesh et al. [21]. The purpose of heat generation/absorption is to decrease and increase a fluid's thermal conductivity, correspondingly. The temperature of the high-conductivity fluid rises, while the low-conductivity fluid exhibits the reverse behaviour. Noor et al. [22]. Using the power series technique, Qasim [23] examined the effects of the heat sink/source around the temperature and mass movement on a vertical stretching plate.

Many studies have demonstrated the use of hybrid nanofluid in high-tech applications, including coolant in automobile engines, nuclear power plants, and electrical appliances (Ahmed et al., [24]). Hybrid nanofluid flow has been demonstrated in several physical models. Alghamdi et al. [25] investigated the MHD flow and heat transmission for the Casson hybrid nanofluid problem. After that, Abbas et al. [26] looked into how stagnation point flow at vertical stretched surfaces was affected by viscous dissipation, MHD, thermal slip, and nonlinear radiative heat transfer. Mahabaleshwar et al. [27] investigated the MHD flow and radiative heat transfer of a Cu–Al2O3/H2O hybrid nanofluid placed under velocity slip conditions over a porous stretch/shrink surface.

There has not yet been any research done on the mass along with heat transmission of the MHD composite nanofluid through the squeezing of a pair of parallel plates acting as thermal radiation sources, with vanadium pentoxide (V2O5) acting as the solid material (nanoparticle), to the best of our knowledge. Squeezing Jeffrey's hybrid nanofluid flow due to its complexity in terms of governing equations has generally received little attention. Therefore, this research is aimed at obtaining the mathematical solutions of the Mass and heat transfer in radiant-MHD vanadium pentoxide (V2O5)-based squeezing flow Jeffrey nanofluid hybrids are equipped with a source or heat generation/ absorption (i.e., filling the void left by Noor and Shafie [28]), and hence compare the present result with the existing ones.

2. Description of the Problem

This research will contain a numerical solution describing the behaviour of the hybrid nanofluid Jeffrey squeezed between a pair of parallel plates. However, our study would focus on the effects of radiant heating, magnetic field on the fluid flow and the heat source/sink on the general flow pattern. Thus, the fluid flow would consider to be squeezing, Newtonian and incompressible.

We study the unstable squeezed Jeffrey hybrid nanofluid flow across a pair of plates over a porous material with magnetohydrodynamic, heat generation/absorption as well as chemical reaction. Vanadium peroxide hybrid nanoparticles are taken into consideration. There is a detachment y between two sheets as shown on the figure1 below. Both the top and bottom plates are subject to the peripheral speed of v_2 also as shown on fig1 below. Up to t=1/α, the two separate sheets shift away when $\alpha < 0$ but nearer when $\alpha > 0$, just as shown on fig. 1 below. The bottom surface is exerted with magnetic field, $B(t) = B_0(1-\alpha t)^{-1/2}$ vertically Noor et al. [29].

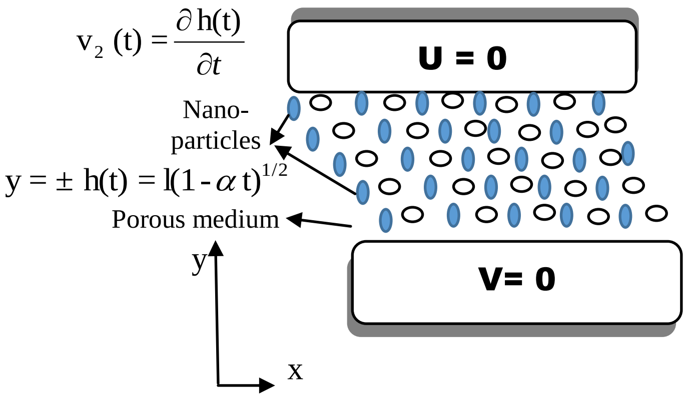

Figure 1. The fluid flow model.

Muhammad et al. ([30], [31]) articles contain a more general formulation of the Jeffrey hybrid nanofluid's momentum, temperature, nanoparticle concentration, and continuity equations.

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

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial x} = \frac{\mu_{hnf}}{\rho_{hnf}}\left(1+\frac{1}{\lambda_1}\right)\frac{\partial^2 v}{\partial y^2} + \frac{\mu_{hnf}}{\rho_{hnf}}\frac{\lambda_2}{1+\lambda_1}\left(\frac{\partial^3 v}{\partial t \partial y^2} + u\frac{\partial^3 u}{\partial x \partial y^2} + v\frac{\partial^3 u}{\partial y^3} - \frac{\partial u}{\partial x}\frac{\partial^2 u}{\partial y^2} + \frac{\partial u}{\partial y}\frac{\partial^2 u}{\partial x \partial y}\right) - \frac{\sigma_{hnf}B(t)}{\rho_{hnf}}u - \frac{\mu_{hnf}}{\rho_{hnf}}\left(1+\frac{1}{\lambda_1}\right)\frac{\varphi}{k_1(t)}u = 0, \quad (2)$$

$$\frac{\partial T}{\partial t} + u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} = \frac{k_{hnf}}{(\rho Cp)_{hnf}}\frac{\partial^2 T}{\partial y^2} + \frac{\mu_{hnf}}{(\rho Cp)_{hnf}}\left(1+\frac{1}{\lambda_1}\right)\left[4\left(\frac{\partial u}{\partial x}\right)^2 + \left(\frac{\partial u}{\partial y}\right)^2\right] - \frac{1}{(\rho Cp)_{hnf}}\frac{\partial q_r}{\partial y} + \frac{Q(T-T_\infty)}{\rho_{hnf}} = 0, \quad (3)$$

$$\frac{\partial C}{\partial t} + u\frac{\partial C}{\partial x} + v\frac{\partial C}{\partial y} = D_m\frac{\partial^2 C}{\partial y^2} - k_c\left(C - C_\infty\right) = 0, \quad (4)$$

Subject to the boundary conditions

$$u = 0, v = v_w = \frac{\partial h(t)}{\partial t}, T = T_w, C = C_\infty, \ at \ y = h(t), \quad (5)$$

$$\frac{\partial u}{\partial y} = \frac{\partial^3 u}{\partial y^3} = \frac{\partial T}{\partial y} = \frac{\partial C}{\partial y} = v0, at \ y = 0, \quad (6)$$

Table 1.0 Thermophysical properties of the fluid and solid particles, Madaki et al. [32], [33]

Physical Properties	Fluid phase (water)	Vanadium Pentoxide (V_2O_5)
$C\rho$ (j/Kg k)	4179	127.7
ρ (Kg/m^3)	997.1	3.35
K (W/mK)	0.613	4.22
$\sigma(\mu S/cm)$	0.05	13.0

According to the Stefan-Boltzmann rule, the amount of radiation absorbed q_r over period of time departing an object corresponds with a fourth of a degree of the temperature in absolute terms, or $q_r = \sigma T^4 A$. This represents the radiation heat fluctuation. Where T is the fundamental temperature, A is the emitting body's area, σ is the Stefan Boltzmann constant, and q is the heat transfer per unit time (ω). Nevertheless, Roseland [34] also clearly expressed the radiative heat flux factor that appears in equation (4) as

$$q_r = -\frac{4\sigma^*}{3k^*}\frac{\partial T^4}{\partial y}$$

According to some studies by [4] and [35], it is thought that the term T^4 may be represented as a function of temperature and that the temperature differential inside the flow is significantly limited. As a result, the higher-order constants are ignored and T^4 is enlarged using the Taylor series expansion around T_∞. As a result, we devise

$$T^4 = T_\infty^4 + 4T_\infty^3 T - 4T_\infty^4$$

$$T^4 = 4T_\infty^3 T - 3T_\infty^4$$

Substituting eqs. (7) and (8) into (3), gives

$$\frac{\partial T}{\partial t} + u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} = \frac{k_{hnf}}{(\rho Cp)_{hnf}}\frac{\partial^2 T}{\partial y^2} + \frac{\mu_{hnf}}{(\rho Cp)_{hnf}}\left(1+\frac{1}{\lambda_1}\right)\left[4\left(\frac{\partial u}{\partial x}\right)^2 + \left(\frac{\partial u}{\partial y}\right)^2\right] + \frac{16\sigma^* T_\infty^3}{3k^*}\frac{\partial^2 T}{\partial y^2} + \frac{Q(T-T_\infty)}{\rho_{hnf}} = 0, \quad (9)$$

3. Method of solution with Runge-Kutta fourth order and shooting scheme combined

We used the same non-dimensional variables as in [28] to transform the mechanism of partial differential system (PDEs) into ordinary differential system (ODEs).

$$u = \frac{ax}{2(1-at)}f'(\eta), v = -\frac{al}{2\sqrt{(1-at)}}f(\eta), \quad (10)$$

$$\eta = \frac{y}{l\sqrt{(1-at)}}f'(\eta), \theta = \frac{T}{T_w}, \varphi = \frac{C}{C_w}$$

When the similarity variables (8) are substituted into equations (1)–(4), the resulting non-dimensional ODE is:

$$\frac{\mu_{hnf}}{\mu_f}\frac{\rho_f}{\rho_{hnf}}\left(1+\frac{1}{\lambda_1}\right)f^{iv} - S\left(\eta f''' + 3f'' + f f'' - f f'''\right) + \frac{\mu_{hnf}}{\mu_f}\frac{\rho_f}{\rho_{hnf}}\left(1+\frac{1}{\lambda_1}\right)\frac{De}{2}\left(\eta f^{v} + 5f^{iv} + 2f'f''' - f f^{iv} - f f^{v}\right) - \frac{\sigma_{hnf}}{\sigma_f}\frac{\rho_f}{\rho_{hnf}}Ha^2 f'' - \frac{\mu_{hnf}}{\mu_f}\frac{\rho_f}{\rho_{hnf}}\left(1+\frac{1}{\lambda_1}\right)\frac{1}{Da}f'' = 0, \quad (11)$$

$$\frac{(\rho Cp)_f}{(\rho Cp)_{hnf}}\frac{k_{hnf}}{k_f}\frac{1}{\Pr}\left(1+\frac{4}{3}Rd\right)\theta'' + S\left(f\theta' - \eta\theta'\right) + \frac{(\rho Cp)_f}{(\rho Cp)_{hnf}}\gamma\theta + \frac{\mu_{hnf}}{\mu_f}\frac{(\rho Cp)_f}{(\rho Cp)_{hnf}}Ec\left[\left(1+\frac{1}{\lambda_1}\right)\left[(f'')^2 + 4\delta^2(f')^2\right]\right] = 0, \quad (12)$$

$$\frac{1}{Sc}\varphi'' + Sc\left(f\varphi' - \eta\varphi'\right) - R\varphi = 0, \quad (7) \quad (13)$$

These are the associated boundary conditions

$$f(\eta) = 0,\ f''(\eta) = 0,\ f^{iv}(\eta) = 0,\ \theta(\eta) = 0,\ \varphi'(\eta) = 0 \quad at\ \eta = 0,$$

$$f(\eta) = 1,\ f'(\eta) = 0, \theta(\eta) = 1, \varphi(\eta) = 1\ at\ \eta = 1, \quad (14)$$

The following lists are the correlations between the thermophysical characteristics of the hybrid nanofluid:

$$\frac{\mu_{hnf}}{\mu_f} = \frac{1}{(1-\phi_{hnf})^{2.5}}$$ Dynamic viscosity (μ) (8) (15)

$$\rho_{hnf} = (1-\phi_{hnf})_{\rho f} + \phi_{V_2O_5}$$ Density of hybrid nanofluid (ρ) (16)

$$(\rho Cp)_{hnf} = (1-\phi_{hnf})(\rho Cp)_f + \phi_{v_2O_5}(\rho Cp)_{v_2O_5}$$ Heat capacity (ρCp) (17)

$$\frac{\sigma_{hnf}}{\sigma_f} = \left[1 + \frac{3\phi_{hnf}\left(\phi_{v_2O_5}\sigma_{v_2O_5}\right)}{\phi_{v_2O_5}\sigma_{v_2O_5} + 2\phi_{hnf}\sigma_{hnf} - \phi_{hnf}\sigma_f \left(\phi_{v_2O_5}\sigma_{v_2O_5} - \sigma_f(\phi_{v_2O_5}\sigma_{v_2O_5})\right)}\right]$$

Electrical conductivity (σ) (18)

$$\frac{k_{hnf}}{k_f}=\frac{\dfrac{\left(\rho_{V_2O_5}k_{V_2O_5}+\phi_{hnf}k_{V_2O_5}\right)}{\phi_{hnf}}+2k_f+\left(\phi_{V_2O_5}k_{V_2O_5}-2\phi_{V_2O_5}k_f\right)}{\left(\dfrac{\phi_{V_2O_5}k_{V_2O_5}}{\phi_{V_2O_5}}\right)+2k_f-\left(\phi_{V_2O_5}k_{V_2O_5}\right)+\phi_{V_2O_5}k_f}$$

Thermal conductivity (k) (19)

The substantial expressions from the governing equations are defined as

$$Rd=\frac{4\sigma^{*}T_{\infty}^{3}}{k^{*}k_f},\ S=\frac{\alpha l^2}{2v_f},\ Ha=lB_0\sqrt{\frac{\sigma}{\rho_f v_f}},\ R=\frac{ak_2l^2}{v_f},$$

$$Sc=\frac{v_f}{D_m},\ \Pr=\frac{v_f}{\alpha_f},\ Da=\frac{k_0}{\varphi l^2},\ \gamma=\frac{Q_0 l^2}{v_f(\rho Cp)_f},$$

$$Ec=\frac{\alpha^2x^2}{4C_pT_w(1-at)^2},\ De=\frac{\alpha\lambda_2}{1-at},\ \delta=\frac{1}{x}(1-at)^{\frac{1}{2}},$$

4. Results and Discussion

This portion includes a brief explanation for better comprehension as well as graphical representations of the characteristics of fluid profiles for many relevant parameters. For hybrid nanofluid containing vanadium pentoxide, the important features of the heat radiation parameter, squeezing number, Eckert number, chemical reaction, ratio of retardation time parameter, and some other relevant factors on fluid profiles are described in depth. Additionally, table 1 above discusses the thermophysical characteristics of hybrid nanoparticles. By applying appropriate similarity transformations, the flow's governing equations are converted into ODEs. Using a shooting technique, via the Runge–Kutta–Fehlberg fourth–fifth-order (RKF 45) approach, the modified collection of ODEs is solved. To validate the current finding for −f (1), Table 2 has been produced using published results from Noor and Shafie [28] and Jyothi et al. [36]. Whereas, table 3, shows the computed values for the reduced Sherwood number concerning the thermal radiation parameter and the squeeze number. It is clear that irrespective of the values of the thermal radiation the result remains unchanged. No wonder because the radiation parameter does not appear in the concentration equation, hence, a change in its values may not necessarily make any significant change. For the values of (S < 0) including (S = 0), it can be heeded that an increase in the values of the parameter decreases the Sherwood number. In contrast, for the values of (S > 0), it can be seen clearly that raise in the values of the parameter increases the values of the Sherwood number. The momentum profile f(η) for a range of Deborah number De values is shown in Figure 2 depicts the thermodynamic changes in the temperature profile for Deborah number (De). It is observed that as Deborah's number increases, the thermal field decreases. The reason for this is that a rise in Deborah's number lowers the fluid's kinematic viscosity, which lowers the system's temperature. Furthermore, Figure 3 illustrates the temperature inclining with a higher Hartmann number. It is demonstrated that the fluid's temperature increases when a magnetic field is applied to its lower surface. The flow's resistance is increased by the Lorentz force that MHD produces.

Table 2.0 Numerical results of $-f''(1)$ for Squeeze number (S)
With $\lambda_1\to\infty$, Da→∞, De→∞, Ha = Ec = δ = γ = R = φ_2 = **0** and Sc = Pr = 1.

Squeeze number **(s)**	Jyothi et al. [36] $-f''(1)$	Noor and Shafie [28] $-f''(1)$	Present result $-f''(1)$
-1.0	2.170090	2.170255	2.170223
-0.5	2.617403	2.617512	2.617391
0.01	3.007133	3.007208	3.007001
0.5	3.336449	3.336504	3.336620
2.0	4.167389	4.167411	4.167389

Table 3.0 Computations showing the reduced Sherwood number ($-\varphi'(0)$) When $\Pr=15,\gamma=1.5,Ec=5.0,\delta=14,Sc=1,R=3$

Thermal radiation **(Rd)**	Sher $S=-5$	Sher $S=-1$	Sher $S=0$	Sher $S=1$	Sher $S=5$
0	0.8926	0.8827	0.6326	0.6619	0.7021
1	0.8926	0.8827	0.6326	0.6619	0.7021
3	0.8926	0.8827	0.6326	0.6619	0.7021
5	0.8926	0.8827	0.6326	0.6619	0.7021
7	0.8926	0.8827	0.6326	0.6619	0.7021

Figure 4 shows how the temperature profile is affected by the Eckert number Ec. As the Eckert number increases, so does the temperature profile. The reason for this is that heat energy is released into the fluid due to frictional forces, which increases the temperature field in the flow region. In addition, the temperature field rises when viscous dissipation occurs. Since the temperature equation directly mentions the Eckert number, adjusting the number's values can readily influence the temperature field.

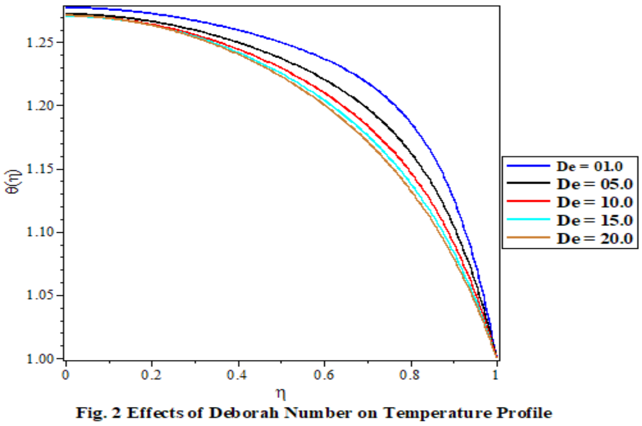

Fig. 2 Effects of Deborah Number on Temperature Profile

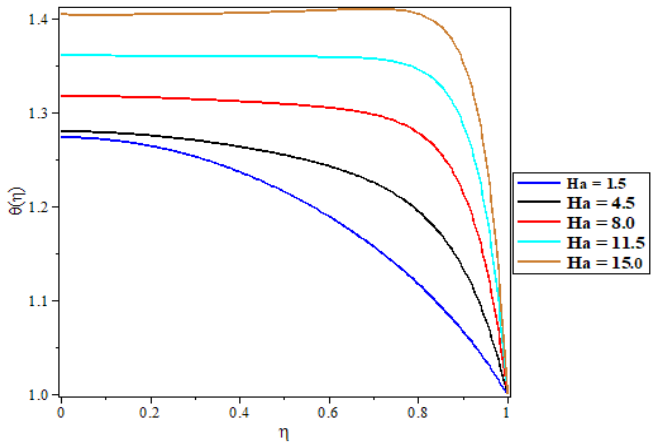

Fig. 3 Effects of Hartmann Number on Temperature Profile

The effects of the retardation time parameter (λ) ratio on the temperature field are shown in Figure 5. It can be seen that the temperature profile drops and the thermal field grows as (λ) increases. This is due to the working fluid's temperature rising during the heat generation process. The flow zone experiences an increase in the thermal field as a result. Moreover, an exothermic chemical reaction can lower the temperature field.

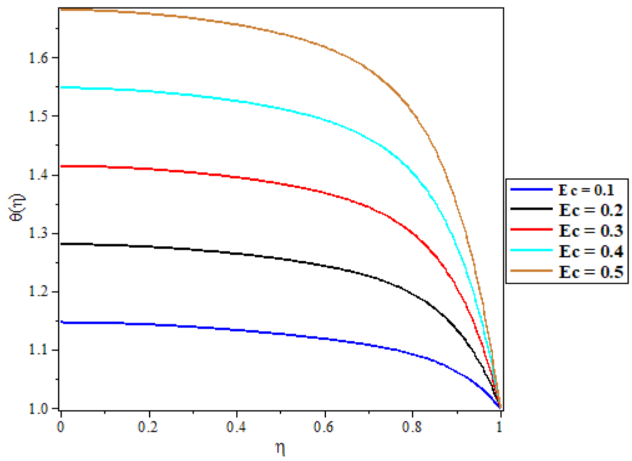

Fig. 4 Effects of Eckert Number on Temperature Profile

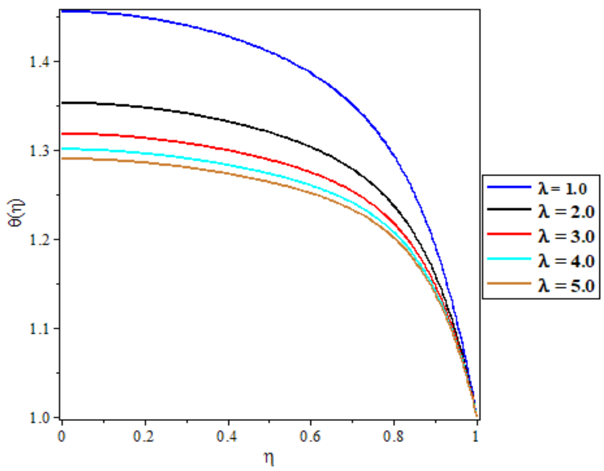

Fig. 5 Effects of Ratio of Retaerdation Time on Temperature Profile

Figure 6 shows the thermodynamic changes in flow profiles that are seen when the squeezing number (S) is applied. In the current investigation, the values of S > 0 indicate that the plates are moving apart from each other, while S < 0 indicates that they are getting closer. The relationship between squeeze number and temperature profile shows that for S < 0, the temperature profile drops, while for S > 0, it grows. The longer distance between the plates causes the fluid's kinematic viscosity to drop, which in turn increases the speed of the plates and lowers the temperature field. This is the cause of the temperature field's decline. Figure 7 is on the effects of thermal radiation Rd on the temperature profile, on this it can be observed that for any increment in the values of radiation parameter the temperature

Furthermore, the effects of thermal radiation on the Nusselt number profile are depicted Figure 8 makes it clear that a rise in the radiation parameter values results in a corresponding decrease in the Nusselt number profile. Figure 9 illustrates how the thickness of the thermal boundary layer reduces as the curves get steeper and the Prandtl number rises. The result is an increase in the lowered Nusselt number, which is proportionate to the starting slope. The free convective boundary layer flow in a typical fluid is similar to this pattern. Figure 10 portrays the concentration declining with an increase in the Hartmann number Ha. Empirical evidence indicates that the lower surface magnetic field slows down the fluid concentration.

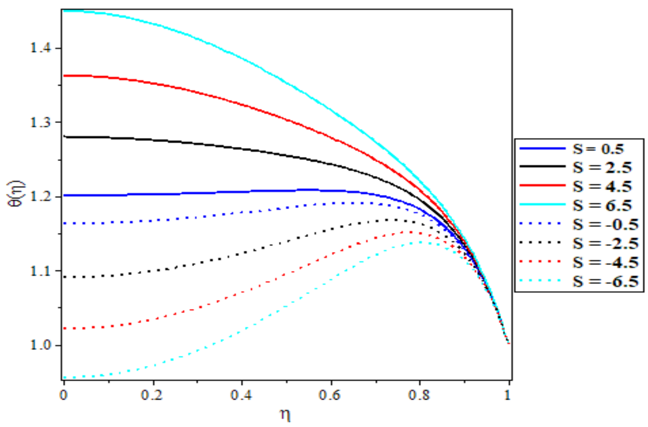

Fig. 6 Effects of Squeeze Number on Temperature Profile

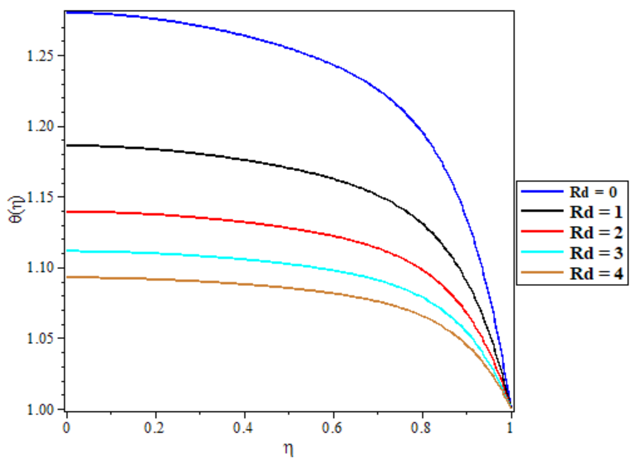

Fig. 7 Effects of Radiation parameter on Temperature Profile

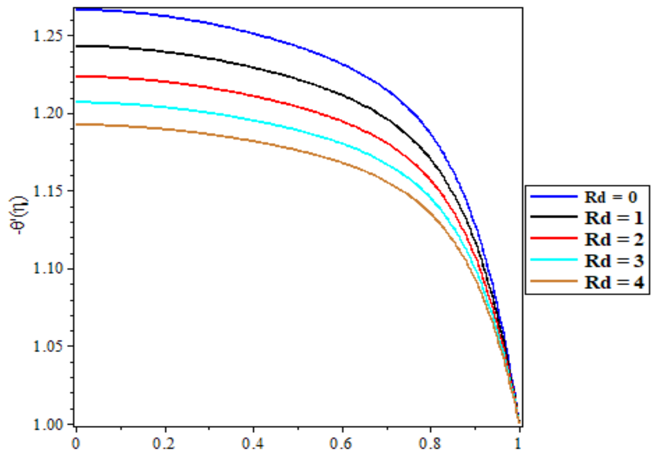

Fig. 8 Effects of Radiation Parameter on Nusselt Number Profile

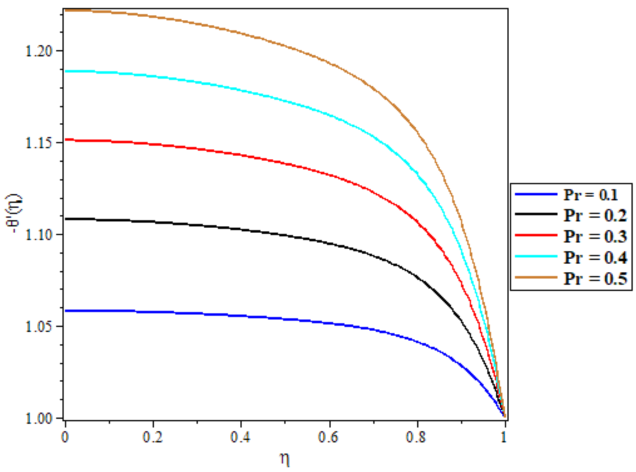

Fig. 9 Effects of Prandtl Number on Nusselt Number Profile

The flow's resistance is increased by the Lorentz force that MHD produces. Figure 11 shows how the chemical reaction parameter R affects the Nusselt number profile; in this instance, an increase in the chemical reaction parameter results in a corresponding drop in the Nusselt number profile. And lastly, the effects of the squeeze number over the profile of concentration are displayed in Figure 12, in such a way that any increment in the squeeze number, produces an increment in the concentration profile.

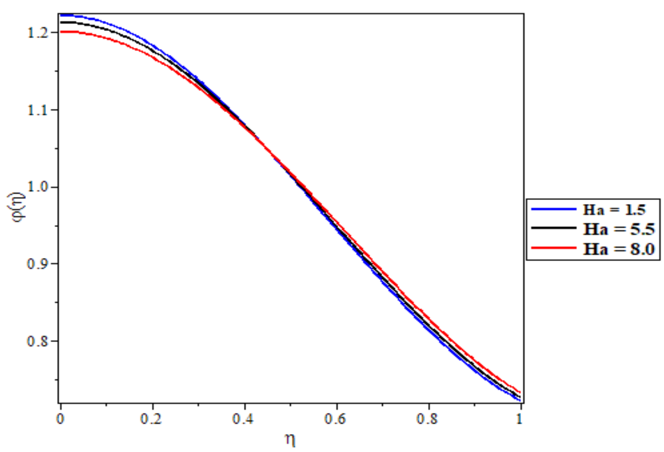

Fig. 10 Effects of Hartmann Number on Concentration Profile

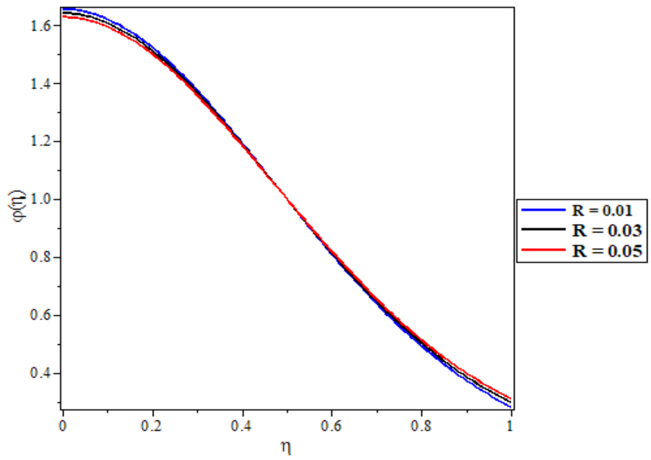

Fig. 11 Effects of Chemical Reaction Parameter on Concentration Profile

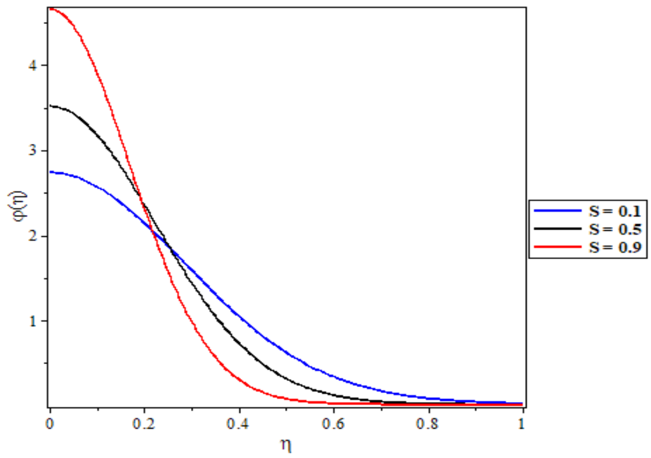

Fig. 12 Effects of Squeeze Number on Concentration Profile

5. Conclusion and Future Scope

For this study, we investigated the Casson hybrid nanofluid flow behaviour between two parallel plates while taking heat radiation and particle deposition of vanadium pentoxide (V_2O_5) into account. The governing equations that illustrate the fluid flow are then converted into non-linear ODEs with the support of appropriate similarity variables. The resulting equations are then numerically solved using the shooting technique and the RKF 45 scheme. Subsequently, Graphs are used to show how some relevant parameters affect various fluid profiles. The following is a summary of the findings above:

1. The momentum profile accelerates with an increase in Deborah's number, while the reverse is observed for the temperature profile.
2. The temperature and concentration profiles are enhanced with an increase in the Hartmann number.
3. The temperature is seen to increase with an increase in the Eckert number.
4. An increase in the ratio retardation time parameter, results in a decrease in the temperature, while in the case of concentration, reverse is observed.
5. The momentum profile is said to decrease as soon as the planes remain squeezed ($S > 0$) while it slows down when the planes are disjointed ($S < 0$) in the medium of the

channel. While in both cases the temperature profile is said to increase.
6. The temperature profile is seen to increase with an increase in thermal radiation parameter whereas the Nusselt number profile is seen to decrease.
7. The Nusselt number profile is increased with an increase in the Prandtl number
8. The concentration profile is decreased with an increase in the chemical reaction parameter.

Data Availability (Size 10 Bold)
None.

Conflict of Interest
The authors declare that they have no competing interests.

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Authors' Contributions
A.G. Madaki initiated the work, studied the literature and developed the study. A.A. Hussaini is concerned with protocol outcomes, achieving ethical endorsement, patient recruitment, and data analysis. Lare wrote the first draft of the manuscript and wrote the final draft of the manuscript. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

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References

[1] S.U.S. Choi, "Enhancing thermal conductivity of fluids with nanoparticles, in: Developments and Applications of Non-Newtonian Flows', FED- vol. **231**/MDvol. **66**, pp. **99- 105**, **1995**.
[2] A. G. Madaki, A. A. Hussaini, "Modified Mathematical Model on the Study of Convective MHD Nanofluid flow with Heat Generation/Absorption". *Journal of Modern mathematics and Statistics, Vol.* **15**, No. **03**, pp. **39- 46**, **2021**.
[3] Madaki, A.G., Hussaini, A. A., Alaramma, S. K., Musa, A. M., Tata, A. A., Barde, A. "Electron Magnetohydrodynamic (EMHD) Nanofluid flow with triple effects of Chemical reaction, Dufour diffusivity and impermeability of the surface along a slandering stretching sheet". *The Sciencetech, Vol.* ***4****, No* ***1****, pp.* ***23-44***, **2022**. *https://doi.org/10.1007/S10973021- 10569w.*
[4] N.S. Akbar, S. Nadeem, R.U.I. Haq, Z.H. Khan, "Radiation effects on MHD stagnation point flow of nanofluid towards a stretching surface with convective boundary condition", *Chinese Journal of Aeronautics,* Vol. **26**, No **6**, pp. **1389–1397, 2013.**
[5] A.G. Madaki, R. Roslan, M.S. Rusiman, C.S.K. Raju, "Analytical and numerical solutions of squeezing unsteady cu and TiO_2– nanofluid flow in the presence of thermal radiation and heat generation/absorption". *Alexandria Engineering Journal,* Vol. **57** No **2**, pp. **1033-1040, 2018**.
[6] A. G. Madaki, D. G. Yakubu, M. Y. Adamu, R. Roslan, "The study of MHD Nanofluid flow with chemical reaction along with thermophoresis and Brownian motion on boundary layer flow over a linearly stretching sheet, *Journal of pure and applied sciences, Vol.* ***19, No*** **83 – 91**, **2019**.
[7] A.G. Madaki, A. A. Hussaini, S. K. Alaramma, A. M. Musa, A. A. Tata, A. Barde, "Electron Magnetohydrodynamic (EMHD) Nanofluid flow with triple effects of Chemical reaction, Dufour diffusivity and impermeability of the surface along a slandering stretching sheet". *The Sciencetech, Vol.* ***4****, No* ***1****, pp.* **23- 44, 2022.**
[8] A. A. Hussaini, A. G. Madaki, A. M. Kwami "Modified Mathematical Model on the Study of Convective MHD Nanofluid flow with Heat Generation/Absorption", *International Journal of Engineering Research & Technology,* Vol. **10, 09**, **pp. 155- 163**, **2021.**
[9] A. A, Hussaini, A. G. Madaki, S.K. Alaramma, A. Barde, "Numerical Study on the Influence of Thermophores and Magnetic Field on the Boundary Layer Flow Over a Moving Surface in a Nanofluid", *Int. Journal of Scientific Research and Modern Technology. Vol.* **2,** No **1**, pp. **4- 9, 2022.**
[10] C.Y. Wang, "The squeezing of a fluid between two plates", *Journal of Applied Mechanics,* Vol. **43,** No **4**, pp. **579–583**, **1976**.
[11] N. M. Bujurke, P. K. Achar, N. P. Pai "Computer extended series for squeezing flow between plates", Fluid Dynamics *Research* Vol. **16**, No **2- 3**, pp. **173– 187**, **1995**.
[12] M. M. Rashidi, H. Shahmohamadi, S. Dinarvand, "Analytic Approximate Solutions for Unsteady Two-Dimensional and Axisymmetric Squeezing Flows between Parallel Plates", *Mathematical Problems in Engineering*, **2008**, pp. **1- 15**, **2008**. doi:10.1155/2008/935095.
[13] U. Khan, N. Ahmed, S.I. Khan, Z.A. Zaidi, Y. Xiao-Jun, S.T. Mohyud-Din, On unsteady two-dimensional and axisymmetric squeezing flow between parallel plates', *Alexandria Engineering Journal*, Vol. **53,** No **2**, pp. **463–468**, **2014**
[14] N.A.M. Noor, S. Shafie, M.A. Admon, "MHD squeezing flow of Casson nanofluid with chemical reaction, thermal radiation and heat generation/absorption", *Advance Research in Fluid Mechanics and Thermal Science* Vol. **68**, No **2**, pp. **94–111, 2020**.
[15] M. Matinfar, M. Ghasemi, "Solving bvps with shooting method and vimhp", *Journal of the Egyptian Mathematical Society*. Vol. **21**, pp. **354–360, 2013.**
[16] A.G. Madaki, R. Roslan, M.S. Rusiman, C.S.K. Raju, "Analytical and numerical solutions of squeezing unsteady Cu and TiO2-nanofluid flow in the presence of thermal radiation and heat generation/absorption", *Alexandria Engineering Journal, Vol.* ***57****,* ***1033-1040****,* **2018**.
[17] S. U. Mamatha, M. K. Murthy, C. S. K. Raju, M. M. Hoque, "Heat transfer effects on MHD flow of Jeffrey fluid over a shrinking sheet with heat source/sink and mass suction", *International Journal of research in Sciences& Engineering. Special issue, pp.* **85–93, 2018**.
[18] W. A. Khan, O. D. Makinde, Z. H. Khan, "Non-aligned MHD stagnation point flow of variable viscosity nanofluids past a stretching sheet with radiative heat", *International Journal of Heat and Mass Transfer*. Vol. **96**, pp. **525–534, 2016.**
[19] O. D. Makinde, F. Mabood, W. A. Khan, M. S. Tshehla, "MHD flow of a variable viscosity nanofluid over a radially stretching convective surface with radiative heat", *Journal of Molecular Liquids*. Vol. **219**, pp. **624–630, 2016.**
[20] K. Avinash, N. Sandeep, O. D. Makinde, I. L. Animasaun, "Aligned Magnetic Field Effect on Radiative Bioconvection Flow Past a Vertical Plate with Thermophoresis and Brownian motion", *Defect and Diffusion Forum*, Vol. **377**, pp. **127–140**, **2017**. https://doi.org/10.4028/www.scientific.net/ddf.377.127.
[21] B. Mahanthesh, B. Gireesha, I. Animasaun, "Exploration of Non-Linear Thermal Radiation and Suspended Nanoparticles Effects on Mixed Convection Boundary Layer Flow of Nanoliquids on a Melting Vertical Surface", *Journal of Nanofluids*, Vol. **7**, No **5**, pp. **833- 843, 2018.** 10.1166/jon.2018.1521.
[22] N.A.M. Noor, S. Shafie, M.A. Admon, "Heat and mass transfer on MHD squeezing flow of Jeffrey nanofluid in horizontal channel through permeable medium", *PLoS One* Vol. **16**, No **5**, pp. **e0250402**, **2021**.

[23] M. Qasim, "Heat and mass transfer in a Jeffrey fluid over a stretching sheet with heat source/sink", *Alexandria Engineering J*ournal, Vol. **52,** No **4**, pp. **571–575, 2013.**

[24] N. Ahmed, F. Saba, U. Khan, I. Khan, T.A. Alkanhal, I. Faisal, S.T. Mohyud-Din, "Spherical shaped ($Ag-Fe_3O_4/H_2O$) hybrid nanofluid flow squeezed between two riga plates with nonlinear thermal radiation and chemical reaction effects", *Energies* Vol. **12**, No **1, 76, 2018.**

[25] W. Alghamdi, T. Gul, M. Nullah, A. Rehman, S. Nasir, A. Saeed, E. Bonyah, "Boundary layer stagnation point flow of the Casson hybrid nanofluid over an unsteady stretching surface", *AIP Adv*ances Vol. **11**, No **1**, pp. **3- 8, 2021.**

[26] N. Abbas, W. Shatanawi, K. Abodayeh, "Computational analysis of MHD nonlinear radiation Casson hybrid nanofluid flow at vertical stretching sheet', *Symmetry* Vol. **14**, No **7**, **1494, 2022**.

[27] U.S. Mahabaleshwar, H.A. Emad, T. Anusha, "MHD slip flow of a Casson hybrid nanofluid over a stretching/shrinking sheet with thermal radiation", *Chinese Journal of Physics* Vol. **80**, pp. **74–106, 2022.**

[28] N.A.M. Noor, S. Shafie, "Magnetohydrodynamics squeeze flow of sodium alginate-based Jeffrey hybrid nanofluid with heat sink or source", *Case Studies in Thermal Engineering,* Vol. **49**, **pp. 1- 12. 2023.** https://doi.org/10.1016/j.csite.2023.103303

[29] N. A. M. Noor, S. Shafie, M. A. Admon- Matematika, "Unsteady MHD flow of cassonnano fluid with chemical reaction, thermal radiation and heat generation/ absorption", *Matematika,* Vol. **33**, pp. **33- 52, 2019.**

[30] K. Muhammad, T. Hayat, A. Alsaedi, B. Ahmed, "A Comparative Study for Convective Flow of Base Fluid (Gasoline Oil), Nanomaterial (SWCNTs) and Hybrid Nanomaterial (SWCNTs+MWCNTs)", *Applied Nanoscience.*, **2020.**

[31] K. Muhammad, T. Hayat, A. Alsaedi "OHAM Analysis of Fourth-Grade Nanomaterial in the Presence of Stagnation Point and Convective Heat-Mass Conditions", *Waves in Random and Complex Media,* **2021**.

[32] A. G. Madaki, A.A. Hussaini, L. Philemon, "Heat and Mass Transfer in Radiant-Magnetohydrodynamics Squeeze Flow of Vanadium Pentoxide (V_2O_5)-Based Jeffrey Hybrid Nanofluid with Heat Source/Sink", *International Journal of Scientific Research in Mathematical and Statistical Sciences*, Vol. **11**, No **1**, pp.**17-23**, E-ISSN: 2348-4519, **2024.**

[33] A. G. Madaki, A.A. Hussaini, L. Philemon, "Numerical results on the radiative Mhd Squeeze flow of Vanadium Pentoxide (V_2O_5)-Based Jeffrey Hybrid Nanofluid through Porous Parallel Plates", *International Journal Scientific Research in Mathematical and Statistical Sciences*, Vol. **11**, No **1**, pp. **48-55**, E-ISSN: 2348-4519, **2024.**

[34] S. Rosseland, "Astrophysik and atom-theorestische grundlagen", Springer Verlag, Berlin, pp. **41–44**, **1931**

[35] M. Kothandapani, J. Prakash, V. Pushparaj, "Analysis of heat and mass transfer on MHD peristaltic flow through a tapered asymmetric channel", Journal of fluids, Vol. **2015, 2015.**

[36] A. M. Jyothi, R. S. Varun Kumar, J. K. Madhukesh, B. C. Prasannakumara, G. K. Ramesh, "Squeezing flow of Casson hybrid nanofluid between parallel plates with a heat source/ or sink and thermophoretic particle deposition", Heat Transfer, Vol. **50**, No **7**, pp. **7139- 7156**, **2021.**

AUTHORS PROFILE

ABDULLAHI MADAKI GAMSHA - earned his B. Tech, M. Sc., and Ph.D., in Applied Mathematics, from Federal University of Technology, Yola, Nigeria, Abubakar Tafawa Balewa University (ATBU), Bauchi, Nigeria and Universiti Tun Hussien Onn Malaysia, in 2008, 2014 and 2017 respectively. He is currently working as a Senior lecturer in the Department of Mathematical Sciences, ATBU, Bauchi since 2009 to date. Meaning that he does have 15 years of teaching experience and 10 years of research experience. He has published about 29 research articles in reputable international journals including Thomson Reuters (SCI & Web of Science).

ABUBAKAR ASSIDIQ HUSSAINI- earned his B. Sc., PGDE, and M, Sc. in Mathematical Sciences from BUK Kano in 2003, University of Maiduguri 2015, and ATBU Bauchi 2023, respectively. He is currently working as a Class room teacher in the Department of Mathematics (Ministry of Education, Bauchi) at GDSS Shira, Bauchi since 2015. He has published more than 14 research papers in reputed international journals including International Journal of Scientific Research in Mathematical and Statistical Sciences (**IJSRMSS**), The Sciencetech, International Journal of Scientific Research and Modern Technology (**IJSRMT**), International Journal of Scientific Research in Mathematical and Statistical Sciences (**IJSRMSS**) as well as Journal of modern mathematics and Statistics (**MEDWELL PUBLICATIONS**). He is an article reviewer at Scientific & Academic Publishing (SAP) _ American Journal of Computational and Applied Mathematics, USA. And his published papers are also available online. His main research work focuses on Fluids (nanotechnology), Numerical analysis and Computational Mathematics. He has more than 8 years of teaching experience and 3 years of research experience.

PHILEMON LARE- earned her B. Tech. and M. Sc. in Mathematics from ATBU, Bauchi and Federal University Kashere, Gombe, Nigeria in 2020 and 2023 respectively. She worked as a supervisee to the first author during her undergraduate program, she graduated with first class honor. She has published some reasonable number of articles.