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Influences of Irreversibility in Transport of Peristaltic of Hybrid Nanomaterial through a Porous Medium in an Inclined Channel

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Abstract:

The purpose of this work is to determine transferred heat features and irreversible transport peristaltic of nanomaterial fluid through a porous medium with an inclined symmetric channel. Expression of the basic velocity, pressure gradient, temperature, and stream function profiles within the boundary layer are plotted and discussed in detail via various values of the distinct parameters. Nanoparticles of hybrid nanomaterial impacts are also used. In the present article, water is used as a base liquid while nanoparticle contain polystyrene and graphene oxide. Over time, it is observed that there are distinct factors and effects such as magnetic field and porosity parameters. Mathematica software is used for estimating the exact solutions of axial velocity and temperature profiles. Additionally, the resolution of equations are considered under the small Reynolds number and large wavelength approximation. Results with plotting graph access via MATHEMATICA (11) are listed.

Key words : ,Peristaltic Flow , Hybrid Nanomaterial ,Irreversibility, Inclined Channel, Porous Medium.

تأثيرات عدم الانعكاس في النقل التمعجي للمواد النانوية الهجينة عبر وسط مسامي في قناة مائلة

الاء وليد صالح ، احمد مولود عبد الهادي

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الخلاصــة

الهدف الرئيسي من هذا العمل البحثي هو الكشف عن خصائص انتقال الحرارة بالإضافة لعدم الانعكاس على النقل التمعجي للسائل المائي المغناطيسي عبر وسائط مسامية لقناة متماثلة مائلة . تم رسم تغيرات السرعة المحورية او الاساسية , تدرج الضغط , درجة الحرارة , بالإضافة لتدفق المائع داخل المنطقة الحدودية ومناقشتها بشكل تفصيلي عبر اختيار قيم مختلفة للمعلمات المؤثرة والمميزة .كما استخدمت تأثيرات الجسيمات النانوية للمواد النانوية المولدة .هنا، يتم استخدام الماء كسائل أساسي بينما تحتوي الجسيمات النانوية على البولسترين وأكسيد الجرافين.كذلك تم الاخذ بتأثير عوامل متميزة مثل المغناطيسية ، معلمة المسامية. تم الحصول على الحل الحقيقي لكل من السرعة المحورية والحرارة . بالإضافة لذلك ، تم الاخذ بالاعتبار المعادلات ذات العلاقة بالمسالة لعدد رينولد صغير وطول طويل للموجة . النتائج والرسوم المتضمنة للعمل تم الحصول عليها من خلال استخدام برنامج (11) MATHEMATICA .

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1- Introduction

Now days, due to the effects of peristalsis experience in various industrial and biological aspects, many articles have concerned with this subject. Peristaltic is a pattern of the transfer of fluid that caused by constriction or extension by the region of flexible channel over the length. Because of peristaltic motion mechanism and its extensive using in medical engineering and medical field, it is considered extensively by recent investigators. At consideration of suspension of different nanoparticles combinations with base fluids, therefore this newly formed of nanofluids is termed as hybrid nanofluids. Nevertheless , publication in [1] , the work by Choi of the Argonne National ,USA, representing anomalous increasing in conductive of thermal at base of fluid with low volume of nanoparticles . The nanoparticles shapes and slip features in peristalsis driven motion of magneto hybrid nanoliquid has been exhibited by Iftikhar et al.[2]. Zahan et al.[3] have shown that, while the impact of connective in hybrid nanoliquid flow first work on hybrid nanoliquid in heat energy has been paying attention by Sheriff et al.[4]. Most of research material like in Kareem and Abdulhadi [5] display heat and mass impacts on Hydrodynamic Peristaltic. Initial discussion of Mechanism of peristaltic transport is natural increased to expansion and contraction of symmetric channel. The movement that was determined by Saleem et al.[6] which was through tube contain hybrid nanomaterial. The important investigating of peristaltic motion in no uniform channel has been disclosed by Akbar et al.[7]. Almost studies [8,11] deal with MHD problems under different looks. The investigated researches Abbasi et al. & Imran et al. respectively [9,10] represented the flow of peristaltic of fluid attention via features in nanomaterial. Furthermore, in [12] Sheriff et al. dealt with different forms of nanoparticles in a non-uniform channel. Peristaltic flow with nanofluid under effects of heat source, in an inclined channel with two walls was described by Salih and Habeeb in [13]. Peristalsis mechanism has been proven to be very helpful in transportation of fluid.

Now days, some newborn researches applicable in this experience offered and remarkable research outcomes in this regard can be seen in [14-17].

Finally, the plan of current study is to resolve MHD(Magneto-hydrodynamic) fluid with constant viscosity, adopting conservation Laws of mass that appears by simulated equations. Then all obtained results present the physical manner of different emerging parameters that illustrated by many graphics and plots.

2- Mathematical Formulation

We consider MHD fluid flow of water based on hybrid nanofluid in two-dimensional non-uniform asymmetric channel, through a porous medium .The motion is induced magnetic impacts are neglected, while the flow field is effected by the considered uniform magnetic strength B_O . The grapheme oxide and polystyrene are considered the nanoparticle

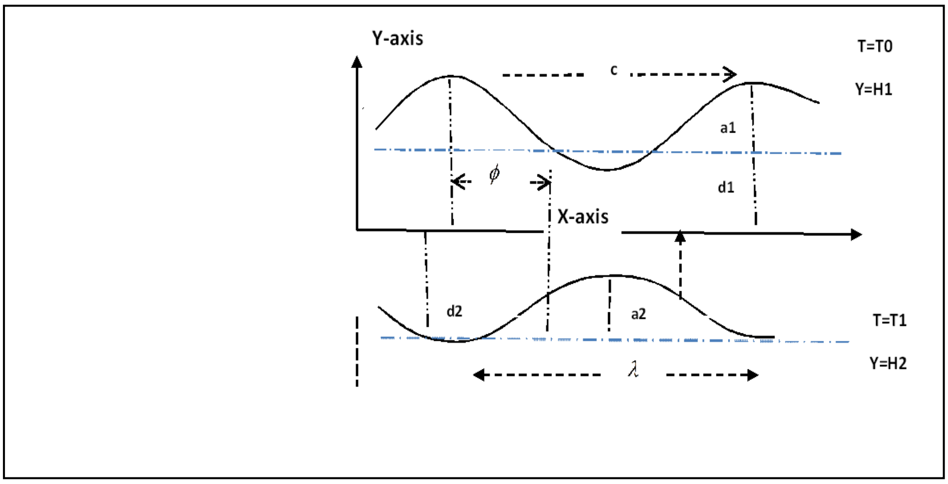


Figure 1: Geometric representation for the flow phenomenon

The equations of walls geometry are stated as follows ..

$$h_1 = d_1 + a_1 \sin\left[\frac{2\pi}{\lambda}\left(\overline{X} - c\bar{t}\right)\right] \qquad \text{Upper wall} \tag{1}$$

$$h_2 = -d_2 - a_2 \sin\left[\frac{2\pi}{\lambda}\left(\overline{X} - c\bar{t}\right) + \varphi\right] \qquad \text{Lower wall} \tag{2}$$

Where $a_1 \& a_2$ show the wave amplitudes of upper wall and lower wall, the wave length is represented by (λ), the velocity wave of peristaltic (c) , the time is ($\bar{t}$) , The Cartesian coordinate denotes by ($\overline{X}$, $\overline{Y}$) , the phase contrast (φ) with symmetric channel.

On the other hand, d_1, d_2, a_1, $a_2 \& \varphi$ satisfy the following association at the inlet of divergent channel

$$a_2^2 + a_1^2 + 2a_2 a_1 Cos(\varphi) \le \left[d_2 + d_1\right]^2 \tag{3}$$

Further, the flow phenomenon is fundamentally unsteady in laboratory coordinate system: $(\bar{X}, \bar{Y}, \bar{t})$. However, the relationship between the two frames is displayed for stable flow by the following form and it can be treated as steady flow in a coordinate system ($\bar{x}$, $\bar{y}$), where we switch form laboratory frame to wave frame.

$$\bar{x} = \overline{X} - c\bar{t} \ , \ \bar{u} = \overline{U} - c, \ \bar{p} = \overline{P}, \ \bar{y} = \overline{Y}, \ \bar{v} = \overline{V} \tag{4}$$

In which the velocity components, pressure and temperature in the wave frame is designated respectively by $\bar{u}$, $\bar{v}$, $\bar{p}$, T .

3- The Governing equations

The governing equations of motion for hybrid nanofluid model, with an inclined asymmetric tapered channel for the current problem are given by[12]:

The Continuity Equations:

$$\frac{\partial \bar{u}}{\partial \bar{x}} + \frac{\partial \bar{v}}{\partial \bar{y}} = 0 \ , \tag{5}$$

The momentum equations:

$$\rho_{hnf}\left[\frac{\partial \bar{u}}{\partial \bar{t}}+\bar{u}\frac{\partial \bar{u}}{\partial \bar{x}}+\bar{v}\frac{\partial \bar{u}}{\partial \bar{y}}\right]=-\frac{\partial \bar{p}}{\partial \bar{x}}+2\frac{\partial}{\partial \bar{x}}\left[\mu_{hnf}\frac{\partial \bar{u}}{\partial \bar{x}}\right]+\frac{\partial}{\partial \bar{y}}\left[\mu_{hnf}\left[\frac{\partial \bar{u}}{\partial \bar{x}}+\frac{\partial \bar{u}}{\partial \bar{y}}\right]\right]-\sigma_{hnf}B_o^2\bar{u} \quad (6)$$

$$-\frac{\mu_{hnf}}{k}\bar{u}$$

$$\rho_{hnf}\left[\frac{\partial \bar{v}}{\partial \bar{t}}+\bar{u}\frac{\partial \bar{v}}{\partial \bar{x}}+\bar{v}\frac{\partial \bar{v}}{\partial \bar{y}}\right]=-\frac{\partial \bar{p}}{\partial \bar{y}}+2\frac{\partial}{\partial \bar{x}}\left[\mu_{hnf}\frac{\partial \bar{v}}{\partial \bar{x}}\right]+\frac{\partial}{\partial \bar{y}}\left[\mu_{hnf}\left[\frac{\partial \bar{v}}{\partial \bar{x}}+\frac{\partial \bar{v}}{\partial \bar{y}}\right]\right], \quad (7)$$

$$\left\langle \rho c_p \right\rangle\left[\frac{\partial \bar{T}}{\partial \bar{t}}+\bar{u}\frac{\partial \bar{T}}{\partial \bar{x}}+\bar{v}\frac{\partial \bar{T}}{\partial \bar{y}}\right]=k_{hnf}\left[\frac{\partial^2 \bar{T}}{\partial \bar{y}^2}+\frac{\partial^2 \bar{T}}{\partial \bar{x}^2}\right]+$$

$$\mu_{hnf}\left[2\left\langle\left\langle\frac{\partial \bar{u}}{\partial \bar{x}}\right\rangle^2+\left\langle\frac{\partial \bar{v}}{\partial \bar{y}}\right\rangle^2\right\rangle+\left\langle\frac{\partial \bar{u}}{\partial \bar{x}}+\frac{\partial \bar{v}}{\partial \bar{y}}\right\rangle^2\right]+\sigma_{hnf}B_o^2\bar{u}^2+\bar{\phi}_o, \quad (8)$$

Where $\bar{u}$ represents the axial velocity along $\bar{x}$ - directions, $\bar{v}$ represents the transverse velocity along $\bar{y}$ - directions, and the temperature is $\bar{T}$.

Here, ρ_{hnf} , μ_{hnf} , σ_{hnf} , $\left\langle \rho c_p \right\rangle_{hnf}$, k , B_o , $\bar{\phi}_o$ and k_{hnf} represent the effective density , dynamics viscosity , electrical conductivity ,heat capacitance , permeability parameter , magnetic strength , heat absorption coefficient and thermal conductivity for hybrid nanomaterial's , respectively.

Now, we introduce the next dimensionless quantities and variables as follows to simplify the governing equations:

$$\left.\begin{array}{l} x=\frac{\bar{x}}{\lambda}, y=\frac{\bar{y}}{a}, u=\frac{\bar{u}}{c}, v=\frac{\bar{v}}{c\delta}, t=\frac{c\bar{t}}{\lambda}, \upsilon=\frac{\mu_f}{\rho}, \phi=\frac{b}{a}, \delta=\frac{a}{\lambda}, p=\frac{a^2\bar{p}}{c\lambda M_f} \\ \vartheta=\frac{\left\{\bar{T}-\bar{T}_o\right\}}{\bar{T}_o}, h_1=\frac{H_1}{d_1}, h_2=\frac{H_2}{d_1}, b_1=\frac{a_1}{d_1}, d=\frac{d_2}{d_1}, b_2=\frac{a_2}{d_1}, \\ M^2=\frac{\sigma_f B_o^2 a^2}{\mu_f}, \beta=\frac{\bar{\phi}_o a^2}{T_o k_f}, Br=\frac{\mu_f a^2 P_r}{\left(c_p\right)_f \overline{\Delta T}} \end{array}\right\} \quad (9)$$

Where $x, y, u, v, \delta, \phi, b_1, b_2, d, t, p, \vartheta$ he components of dimensionless coordinates , the axial velocity , dimensionless of transverse , the wave frame , the amplitudes of upper wall , the amplitudes of lower wall , dimensionless of time , pressure and temperature, respectively. Also, we shall use several dimensionless parameters that are registered above ,*M* the Hartmann number , β represents heat source/sink parameter(heat absorption parameter , and *Br* is the Brinkman number .

By applying the dimensionless variables in (9) , with flow being steady , the equations (5) to (8) become

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0 \quad (10)$$

$$R_e\delta\left[\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}\right]=-\frac{\partial p}{\partial x}+\frac{\partial}{\partial y}\left[\left[\frac{\mu_{hnf}}{\mu_f}\right]\frac{\partial u}{\partial y}\right]-\frac{\sigma_f B_o^2 a^2}{\mu_f}.\left[\frac{\sigma_{hnf}}{\sigma_f}\right].u \quad (11)$$

$$-\left[\frac{\mu_{hnf}}{\mu_f}\right].\frac{a^2}{k}u$$

$$R_e\delta^3\left[\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}\right]=-\frac{\partial p}{\partial y}+2\delta^3\frac{\partial}{\partial x}\left[\left[\frac{\mu_{hnf}}{\mu_f}\right]\frac{\partial v}{\partial y}\right]+\frac{\partial}{\partial y}\left[\left[\frac{\mu_{hnf}}{\mu_f}\right]\left[\delta^3\frac{\partial v}{\partial x}+\delta^2\frac{\partial v}{\partial y}\right]\right], \quad (12)$$

Implementing by long wavelength (δ<<1) and approximating of low Reynolds number, with using relationship between stream function and velocity components that defined down in "Eq.(13)" .

$$u=\frac{\partial\psi}{\partial y} \quad , \quad v=-\delta\frac{\partial\psi}{\partial x} \quad (13)$$

"Eq.(11)" and"Eq.(12)" become

$$\frac{\partial\psi}{\partial x\partial y}-\frac{\partial\psi}{\partial y\partial x}=0 \quad (14)$$

$$\frac{\partial p}{\partial x}=\frac{\partial}{\partial y}\left[\left[\frac{\mu_{hnf}}{\mu_f}\right]\frac{\partial u}{\partial y}\right]-M^2\left[\frac{\sigma_{hnf}}{\sigma_f}\right]u-\left[\frac{\mu_{hnf}}{\mu_f}\right]\frac{1}{D}u, \quad (15)$$

$$\frac{\partial p}{\partial x}=\frac{\partial}{\partial y}\left[\left[\frac{\mu_{hnf}}{\mu_f}\right]\frac{\partial^2\psi}{\partial y^2}\right]-M^2\left[\frac{\sigma_{hnf}}{\sigma_f}\right]\left[\frac{\partial\psi}{\partial y}\right]-\left[\frac{\mu_{hnf}}{\mu_f}\right]\frac{1}{D}\left[\frac{\partial\psi}{\partial y}\right], \quad (16)$$

Further, we introduce the mathematically form for effective thermal diffusivity effective thermal conductivity of hybrid nanomaterial and porosity parameter as follows:

$$T=\frac{\mu_{hnf}}{\mu_f},\ E=\frac{\sigma_{hnf}}{\sigma_f},\ K=\frac{k_{hnf}}{k_f},\ D=\frac{k}{a^2}, \quad (17)$$

$$\frac{\partial p}{\partial y}=0, \quad (18)$$

$$K\frac{\partial^2\vartheta}{\partial y^2}+B_rT\left\langle\frac{\partial^2\psi}{\partial y^2}\right\rangle^2+B_rM^2E\left\langle\frac{\partial\psi}{\partial y}+1\right\rangle^2+\beta=0 \quad (19)$$

By differentiating "Eq.(16)" , we obtain an equation, which is free of pressure gradient as follows:

$$T\frac{\partial^4\psi}{\partial y^4}-M^2E\left[\frac{\partial^2\psi}{\partial y^2}\right]-T\frac{1}{D}\left[\frac{\partial^2\psi}{\partial y^2}\right]=0 \quad (20)$$

The boundary conditions with dimensionless wave frame are:

$$\left.\begin{aligned} &\psi = 0, \quad \frac{\partial^2 \psi}{\partial y^2} = 0, \quad \text{at} \quad y = h_1 \\ &\psi = F_1, \quad \frac{\partial \psi}{\partial y} = -1, \quad \text{at} \quad y = h_2 \end{aligned}\right\} \tag{21}$$

Expression that keeping with subjected boundary conditions (21) , where(F_1) is the non-dimensional mean flow rate in the wave frame:

$$\psi = a_3(e^{a_2 y}c_1 + e^{-a_2 y}c_2) + c_3 + yc_4 \tag{22}$$

where

$$a_1 = \frac{M^2 E}{T} \quad ; \quad a_2 = \sqrt{\frac{1+a_1 D}{D}} \quad ; \quad a_3 = \frac{D}{1+a_1 D} \tag{23}$$

$$\left.\begin{aligned}
c_1 &= -\frac{e^{a_2 h_2}\left(F_1 - h_1 + h_2\right)}{a_3\left(e^{2a_2(h_1-h_2)} - a_2 h_1\left(e^{2a_2 h_1} + e^{2a_2 h_2}\right) + a_2 h_2\left(e^{2a_2 h_1} + e^{2a_2 h_2}\right)\right)} \\
c_2 &= \frac{e^{2a_2 h_1 + a_2 h_2}\left(-F_1 + h_1 - h_2\right)}{a_3\left(-e^{2a_2 h_1} + e^{2a_2 h_2} - a_2 h_1\left(e^{2a_2 h_1} + e^{2a_2 h_2}\right) - a_2 h_2\left(e^{2a_2 h_1} + e^{2a_2 h_2}\right)\right)} \\
c_3 &= \frac{h_1\left(-e^{2a_2 h_1} + e^{2a_2 h_2} + (a_2 F_1)\left(e^{2a_2 h_1} + e^{2a_2 h_2}\right)\right)}{\left(-e^{2a_2 h_1} + e^{2a_2 h_2} + a_2 h_1\left(e^{2a_2 h_1} + e^{2a_2 h_2}\right) - a_2 h_2\left(e^{2a_2 h_1} + e^{2a_2 h_2}\right)\right)} \\
c_4 &= \frac{\left(-e^{2a_2 h_1} + e^{2a_2 h_2} + (a_2 F_1)\left(e^{2a_2 h_1} + e^{2a_2 h_2}\right)\right)}{\left(-e^{2a_2 h_1} + e^{2a_2 h_2} + a_2 h_1\left(e^{2a_2 h_1} + e^{2a_2 h_2}\right) - a_2 h_2\left(e^{2a_2 h_1} + e^{2a_2 h_2}\right)\right)}
\end{aligned}\right\} \tag{24}$$

Now, we introduce the boundary condition of non- dimensional temperature ϑ in the wave frame as follows:

$$\left.\begin{aligned} &\text{At} \quad y = h_1, \quad \frac{\partial \vartheta}{\partial y} = 0, \\ &\text{At} \quad y = h_2, \quad \vartheta + \gamma \frac{\partial \vartheta}{\partial y} = 0 \ . \end{aligned}\right\} \tag{25}$$

The exact solution of temperature Eq.(18), that satisfies the boundary conditions (25), can be obtained as follows:

$$\vartheta = -\frac{y^2\left(B_r((1+a_1)E_1 M^2 + a_2^2 T_1) + \beta\right)}{2k} + c_1 + yc_2 \tag{26}$$

Where

$$\left.\begin{aligned} c_1 &= -\frac{\left((1+a_1)B_r E_1 M^2 + a_2^2 B_r T_1 + \beta\right)\left(2h_1h_2 - h_2^2 + 2\gamma(h_1 - h_2)\right)}{2k}, \\ c_2 &= \frac{h_1\left(\left((1+a_1)B_r E_1 M^2 + a_2^2 B_r T_1 + \beta\right)\right)}{k}, \end{aligned}\right\} \quad (27)$$

The values of coefficient (c_1, c_2) can be determined with the boundary conditions in (25) Eq. , Also, by using MATHEMATICA listing version 11 .

Additionally, we present the solution of axial velocity equation via differentiating of stream function with respect to (y), then we get the form of its term as follows:

$$e^{a2(d_2+d1y+h_2)}(-d_1\sqrt{D_1}e^{a2(d_2+d1y+h_2)}d_1\sqrt{D_1}e^{\frac{a2}{d_1}(2d_1+d_2-d1y+h_2+2h_1)}$$

$$-d_1 - d_2a2 - d_1e^{\frac{2a2}{d_1}(d_1(-1+y)-h_1)}a2 - d_2e^{\frac{-2a2}{d_1}(d_1(-1+y)-h_1)}a2 + d_1F1a2 +$$

$$d_1e^{\frac{-2a2}{d_1}(d_1(-1+y)-h_1)}F1a2 - d_1e^{\frac{-a2}{d_1}(d_2+d_1y+h_2)}F - d_1e^{\frac{a2}{d_1}(2d_1+d_2-d_1y++2h_1+h_2)}F1a2 \quad (28)$$

$$u = \frac{-b_1(1+e^{\frac{2a2}{d_1}(d_1(-1+y)-h_1)}a2h_1 - b_2(1+e^{\frac{-2a2}{d_1}(d_1(-1+y)-h_1)}a2h_2))}{\begin{aligned}&(d_1\sqrt{D_1} - d_1\sqrt{D_1}e^{\frac{2a2}{d_1}(d_1+d_2+h_1+h_2)} + (d_1+d_2)a2 + \\ &(d_1e^{\frac{2a2}{d_1}(d_1+d_2+h_1+h_2)} + d_2e^{\frac{2a2}{d_1}(d_1+d_2+h_1+h_2)})a2 + \\ &+b_1(1+e^{\frac{2a2}{d_1}(d_1+d_2+h_1+h_2)})a2h_1 + b_2(1+e^{\frac{2a2}{d_1}(d_1+d_2+h_1+h_2)})a2h_2))\end{aligned}}$$

4- Graphical results and discussions ..

In this section, we discuss the impact of parameters on axial velocity, magnetic force, pressure gradient, temperature, stream function for various values. The results are described by the graphical clarification while the software program of Mathematica was used to obtain the results. The trapping aspect was also studied and described through graphs.

4.1- Velocity Profile ..

Various parameters that we use to calculate the profile of velocity cross section of the channel. The axial velocity is calculated at the $(x = 2)$ cross section. Clearly in figure (1) form (A-F) parabolic distribution of velocity and at the center of channel it increases. Fig. A provides the value of (M) on the axial velocity, where the increasing in value of it leads to decrease in velocity. We observe that the velocity profile decreases with increasing the value of (ϕ). It may be also noted that the axial velocity variation in apart of channel with alteration in the value of parameter. It is important to note the change of velocity profile near the center when changing values of (x). The influence of the parameters (D_1), (E_1) and (F) on the velocity profile is shown in Figures (D),(E) &(F) .

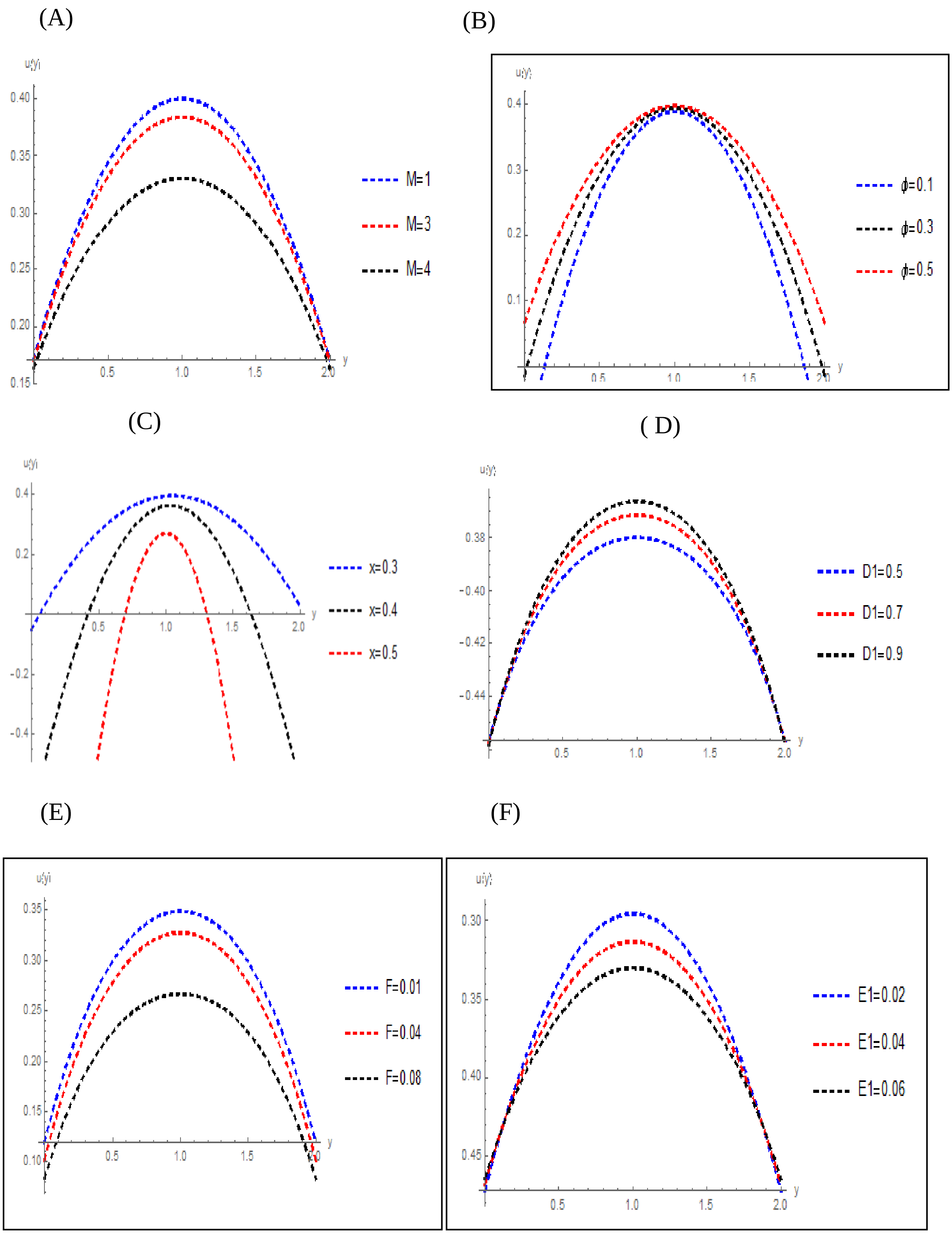
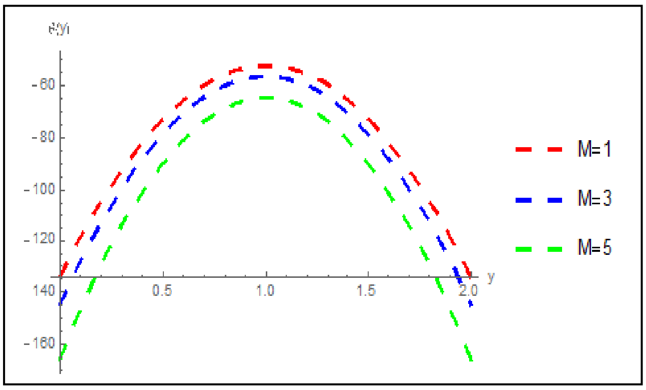


Figure 2: Represents axial velocity profile with different values of parameters such as $\{M=1, \phi=1, D=4, F=0.1, E=0.2, T=4, b_1=0.01, d_1=0.2, b_2=0.1, d_2=0.1, x=1\}$.

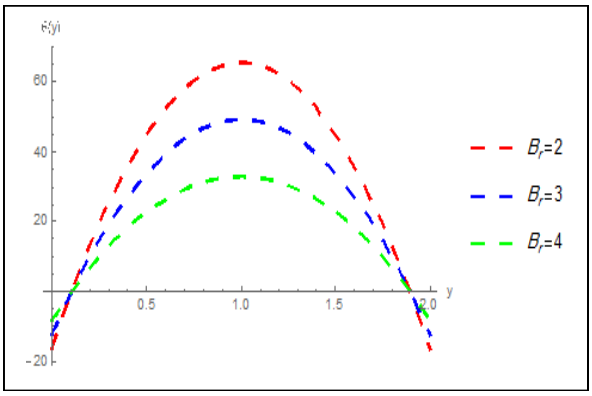
4.2-*Temperature Profile ..*

Figures-3 (A1 –F1) illustrate the impact of heat transfer on peristaltic flow for several values of parameters. The present plots display important information that communicate with the heat transference in the fluid. Fig. (A1) shows the effects of M (Hartman number), on temperature distribution. The temperature curves are dominant for base fluid (water) as compared to hybrid nanofluid in the ranges ($o \leq y \leq 2$). The graphical results show that the temperature increases with decreasing Br (Brinkman number) as represented in Fig.(B1) . Physically, Brinkman number is demonstrated as the quantity to measure irreversibility of fluid resistance. However, the effects of heat source/sink parameter (β) on temperature distribution display in Fig.(C1) .It can be observed that the temperature distribution increases with increasing (φ) and (γ) . When any decreasing in (k) leads to increase the value of temperature.

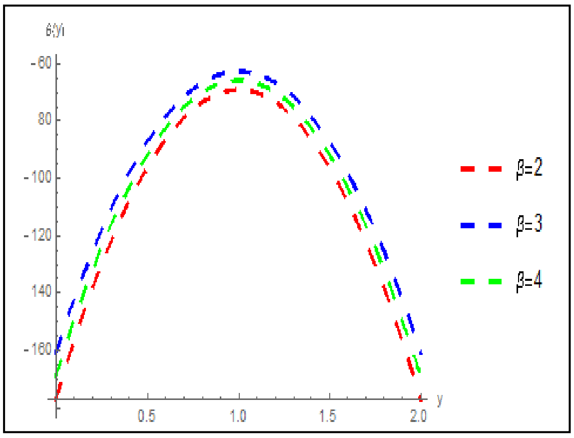
(A1)



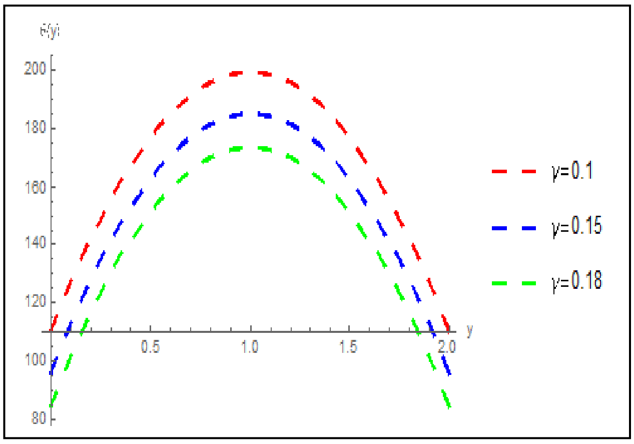
(B1)



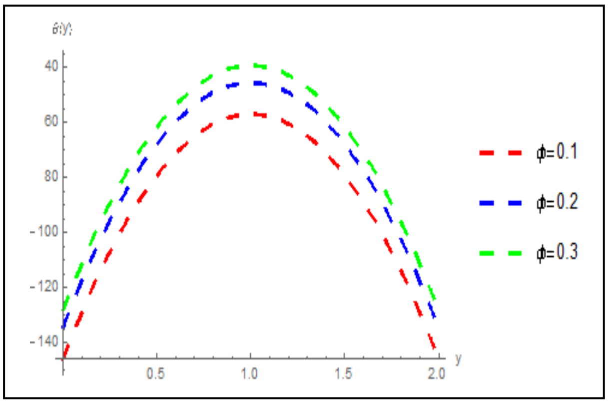
(C1)



(D1)



(E1)



(F1)

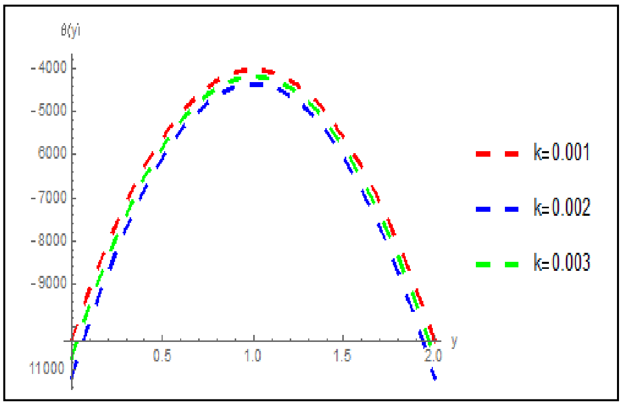


Figure 3: Representing *the Temperature* profile with different values of parameters such as $\{M=1, \phi=1, D=4, F=0.1, E=0.2, T=4, b_1=0.01, d_1=0.2, b_2=0.1, d_2=0.1, x=1\}$.

4.3-*Gradient Pressure behavior ..*

4.3-*Gradient Pressure behavior ..*

The study of behavior of gradient pressure show in Figures (4 – 7) , where the alteration of gradient pressure counter to the axial coordinate x at different wave forms. (D) , (F) , (T) and the amplitude ratio effects on pressure gradient are display in Figures-(4-7). It can be noticed from Figure-3 that increasing porosity parameter leads to increasing the pressure gradient. It is also observed that increasing (F)and (T) leads to increasing the gradient of pressure. In Figure-(6), it is illustrated that increasing of the amplitude ratio (ϕ) leads to decreased pressure gradient. Also, it observed that the flow can be passed simply without imposition of high gradient pressure. The Figures-show that, the pressure gradient gives low magnitude for hybrid nanofluid .

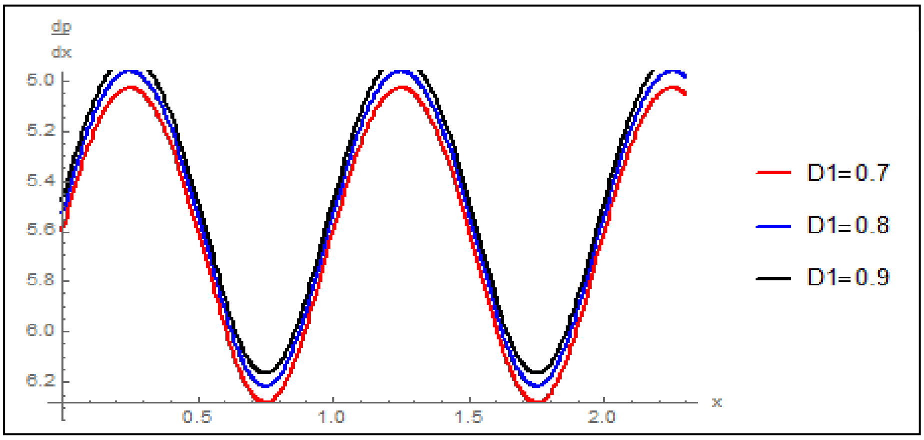


Figure 4: The influence of (D) on ressure gradient profile at $\begin{Bmatrix} M=1,\phi=0.01, \\ F=0.1,E_1=0.2,T=4, \\ b_1=0.01,d_1=0.2,b_2=0.01, \\ d_2=0.1,y=2 \end{Bmatrix}.$

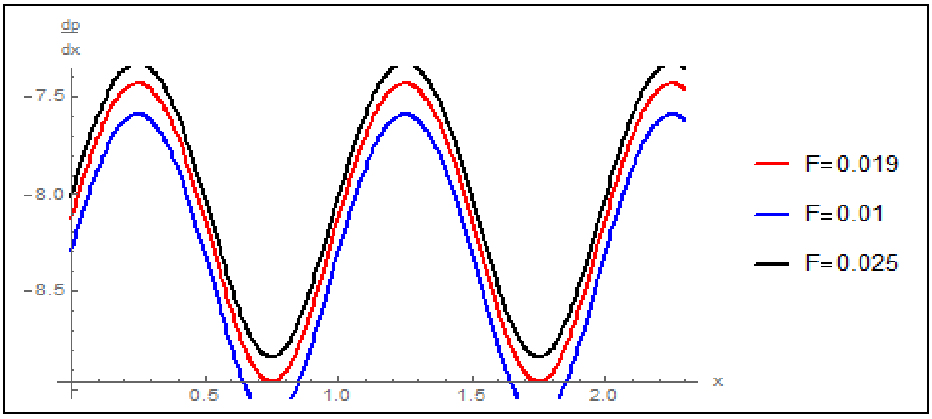


Figure 5: The influence of (F) on pressure gradient profile at $\begin{Bmatrix} M=1,\phi=0.01,D=0.7, \\ F=0.019,E=0.2,T=4, \\ b_1=0.01,d_1=0.2,b_2=0.01, \\ d_2=0.1,y=2 \end{Bmatrix}.$

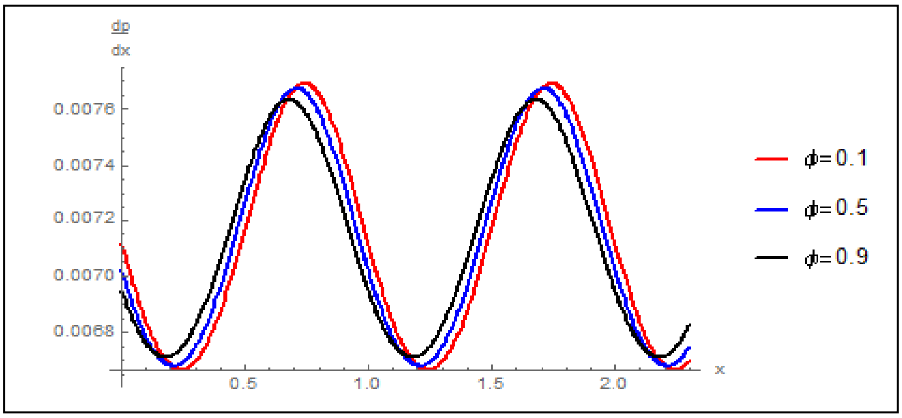


Figure 6: The influence of (ϕ) on pressure gradient profile at $\left\{\begin{matrix} M=1, \phi=0.1, D=0.01, \\ F=0.1, E=0.2, T=4, \\ b_1=0.01, d_1=0.2, b_2=0.01, \\ d_2=0.1, y=2 \end{matrix}\right\}.$

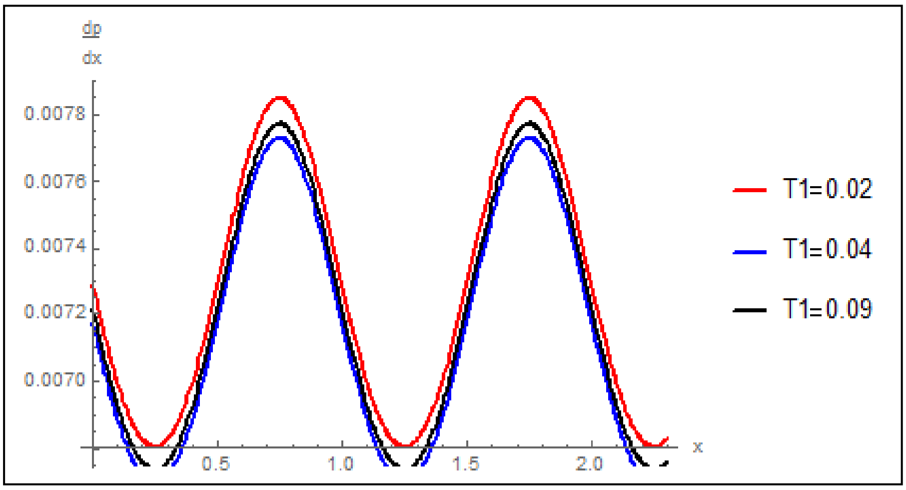


Figure 7: The influence of (T) on pressure gradient profile at $\left\{\begin{matrix} M=1, \phi=0.01, D_1=0.01, \\ F=0.1, E_1=0.2,, b_1=0.01, \\ d_1=0.2, b_2=0.01, \\ d_2=0.1, y=2 \end{matrix}\right\}.$

4.4-*Trapping Phenomena*

Internally circulating of the liquid that formulation by closed streamline, where it is called Trapping. The movement of bolus with same speed of the wave. This phenomenon is useful in avaricious the motion in the arrangement of thrombus characters. Figures-(8-9) show various values of effective parameters on the trapping stream lies. Analyzing the influence of Hartman number (M) on trapping in Figure-8 when observed that the larger size of the bolus becomes larger with the increase of Hartman number. Figure -9 exhibits that the volume of bolus raises with increasing in porosity parameter *(D).*

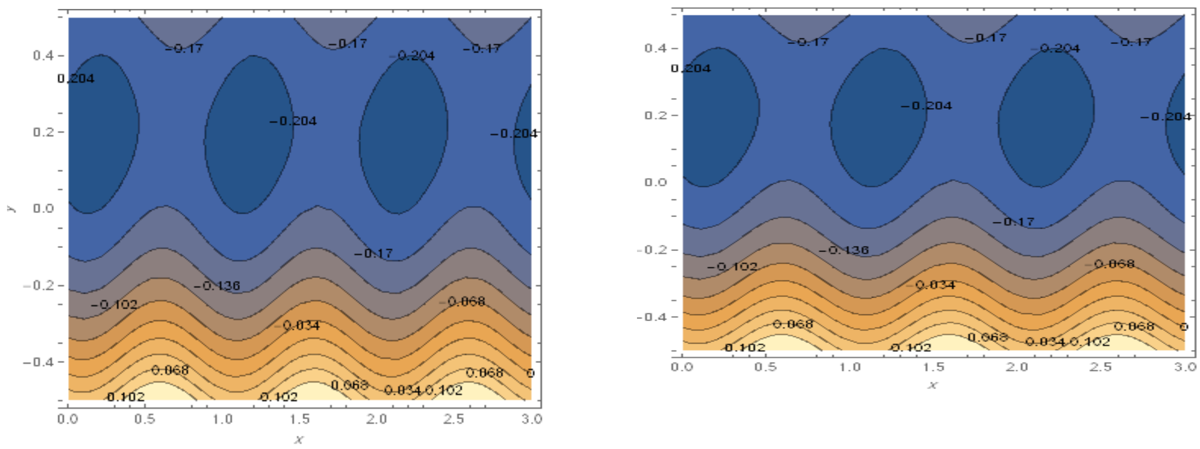


Figure 8: Distinct values of (M) that impact on Stream lines for **(a)** M = 1 ,**(b)** M =2 ,**(c)** M =3 , at various parameters are
$\phi=1, a_1=0.22, a_2=0.12, D=1, F=0.1, E=0.2, T=4, b_{1,}=0.01, b_2=0.01, d_1=0.2, d_2=0.1.$

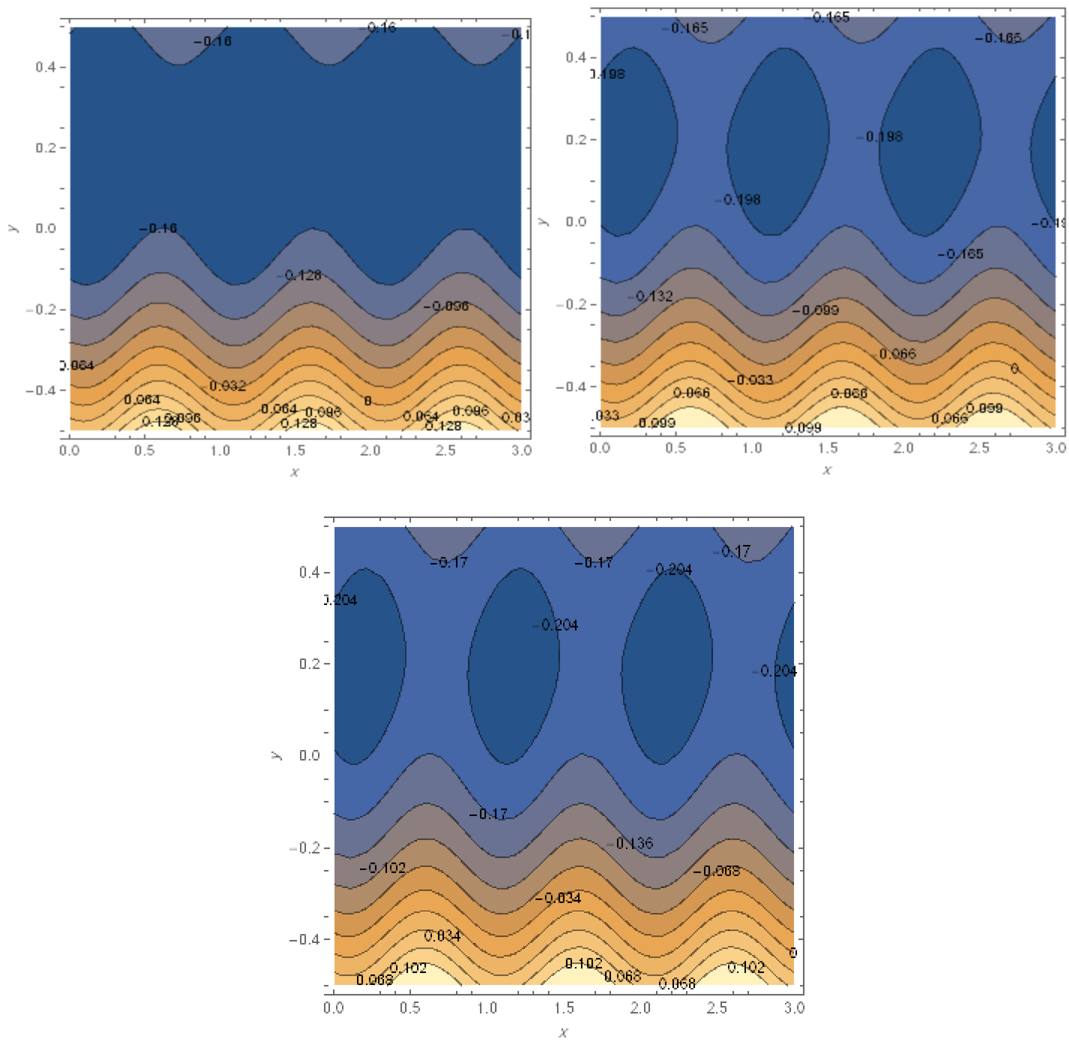


Figure 9: Distinct values of (D) that impact on Stream lines for **(a)** D = 1 ,**(b)** D =3 ,**(c)** D =5 , at various parameters are

$$\phi=1, a_1=0.22, a_2=0.12, M=1, F=0.1, E=0.2, T=4,$$

$$b_{1,}=0.01, b_2=0.01, d_1=0.2, d_2=0.1.$$

Conclusion

The results of this study demonstrate that in MHD hybrid nanofluid flow in non-uniform channel , deal with the impacts of irreversibility , porous media ,induced magnetic of peristaltic movement on convective heat transport of fluid with constant viscosity in two wall , actual physical quantities that shown in the governing of equations of this problem analysis through contrary graphs. The important observations in all these expressions such as axial velocity, temperature , stream function and pressure gradient . We can point out the following conclusions:

A - It was found that the profile of axial velocity takes a parabolic shape as a centered channel with increasing parameters.

B- Hartman number and porosity parameter show opposite behavior on the velocity profile .

C- We ignore that, the temperature value increase when the values of parametric are increasing, while it is higher at the central channel mostly. Further, the temperature curve grows with respect to the Brinkman number.

D - Generally, the pressure gradient profile action oscillatory in the range of the whole x-axis for various values of non-dimensionless wave amplitude T1 and E1. The wave frame on pressure decreases and increases gradually.

E - In the phenomenon of trapping that observes in peristalsis motion, we noted the larger size of bolus increased, and almost the effect of Hartmann number appears when the bolus decrease as its value increases.

F - In fact, physical applications in the transport of peristalsis moving have been considered, due to the contraction and expansion of symmetric channel that appears in various process, such as blood transformation, ureter, and other human body areas.

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