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Influence of concentration and the heat transfer for a ferromagnetic fluid in a porous medium

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Abstract:
This article studies and examine the concentration and heat transfer under long wavelength con[22ditions in an asymmetric channel with a porous medium while an applying a magnetic field and rotation to the peristaltic flow Powell-Eyring. Considering low Reynolds numbers, all nonlinear partial differential equations are extracted using the perturbation method and MATHEMATICA, (19) program. The fluid is subject to a magnetic field and changes in concentration. As it flows within a porous medium, we have used a set of parameters and compared them in terms of (velocity, pressure). Examples of these parameters are Hartmann number (Ha), Darcy number (Da), rotation (Ω), etc. We notice that some parameters affect the increase in velocity and others affect the decrease in velocity, and the same applies to pressure. We use graphs to express the speed and pressure gradient and their effect on the parameters affecting the equations of motion. Using a set of numbers to produce numerical results, the impact of various parameters is explored below and illustrated graphically.

Keywords: Peristaltic flow, MHD, Rotation, Heat transfer

تأثير التركيز وانتقال الحرارة لسائل مغناطيسي حديدي في وسط مسامي

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الخلاصه:
تدرس في هذه المقالة وتفحص التركيز وانتقال الحرارة تحت ظروف الطول الموجي الطويل في قناة غير متماثلة ذات وسط مسامي أثناء تطبيق المجال المغناطيسي والدوران على التدفق التمعجي باول-إيرينج. مع الأخذ في الاعتبار أرقام رينولدز المنخفضة، يتم استخراج جميع معادلات التفاضل الجزئي غير الخطية باستخدام طريقة الاضطراب وبرنامج الرياضيات (19) .MATHEMATICA يتعرض السائل لحقل مغناطيسي وتغيرات في التركيزأثناء تدفقه داخل وسط مسامي. لقد استخدمنا مجموعة من المعلمات وقارناها من حيث (السرعة والضغط). ومن أمثلة هذه المعلمات رقم هارتمان (Ha)، ورقم دارسي (Da)، والدوران (Ω)، إلخ. نلاحظ أن بعض المعلمات تؤثر على زيادة السرعة والبعض الآخر يؤثر على انخفاض السرعة، وينطبق الشيء نفسه على الضغط. نستخدم الرسوم البيانية للتعبير عن تدرج السرعة والضغط وتأثيرهما على المعلمات المؤثرة على معادلات الحركة. باستخدام مجموعة من الأرقام لإنتاج نتائج رقمية، يتم استكشاف تأثير المعلمات المختلفة أدناه وتوضيحها بيانياً.

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1. Introduction.

Fluid transport is achieved through the propagation of wave trains along the channel, utilizing a mechanism known as peristaltic transport. Swallowing food, blood flowing through the bile duct, lymph moving through the lymphatic arteries, urine being delivered through the ureter, chyme moving within the digestive system, and ovum being transported. Other real-world applications are among the many uses of this phenomenon in body structure and biomedical engineering [1] and [2] explored two different scenarios to investigate peristaltic transport: one focused on peristaltic flow without a pressure gradient, while the other examined flow through a tube or channel under pressure. [3 - 6] looked into the peristaltic transport process, which has drawn interest from many scholars. furthermore, many industrial and physiological processes are more familiar with non-Newtonian fluids than with viscous liquids. Powell- Eyring [7] was among these substances characterized by the high polymer ionic solution, among several non-Newtonian substances that are typically found as found in nature, including blood, paints, lubricants, ketchup, and shampoo. in [8] an applied magnetics field's (MHD) advantages for peristaltic effectiveness are critical when discussing the wave form motion of non-Newtonian fluids in porous channel, also see [9 –12]. in addition, it helps to treat morbid obesity, gastroparesis, and magnetic resonance imaging (MRI), which is used detect tumors, Blood vessels, illnesses, brain disorders. A porous medium is a material that contains a number of microscopic holes dispersed throughout it. Flows over porous medium in riverbeds sustain fluid in filtration the flow of oil, water, and groundwater through porous materials are important examples of such fluxes. Most of an oil reservoir is composed of sandstone and limestone rock formations, which are home trapped oil [13]. wood filters, and bread loaves are just a few examples of natural porous media. All of the aforementioned processes [14 –16]. Specifically, the mass transfer which takes place it cannot be overstated that nutrients spread from the blood into surrounding tissues higher participation of mass transmission is generally observed the processes of membrane dissociation, burning, distillation, and the diffusion it ought to note that heated. A Team of investigators discussed how concentration and temperature affect fluid flow the majority of these studies found that while temperature increases the fluid's velocity, variations in concentration and the fluid's position inside the channel cause the fluid's velocity to alter in an unclear way [17]. in this investigation, influence of temperature and concentration on the oscillating flow the magnetizing Eyring -Powell fluid hydrodynamics through a porous medium are to be discussed. And conducted research on the impact rotating to the mixed convection study of heat transport, viscous liquid in an asymmetric regarding the peristaltic movement of asymmetric channel. additionally, he examined the influence rotational movement and also influence to the magnetic field on mixed convection analysis [18]. and the movement a thick liquid fluid via a porous media thermal system and in porous media, the impact of heat transfers on the Powell - Eyring fluid's peristaltic transport was examined when a magnetic field is present via an asymmetric channel [19]. the objective of this research is to examine the peristalsis in transport of Powell - Eying fluid when there is rotation, porous medium, magnetic field.

2. Mathematical formulation for asymmetric flow

The peristaltic motion is incompressible motion to Powell-Eyring fluid with width (d'+ d) in a two-dimensional asymmetric channel. The endless sinewave that flows and travels along the walls of the channel, what is the forward motion (c) that produces the flow. The geometric definition of the wall structure is:

$$\bar{h}_1(\bar{X}, \bar{t}) = d - a_1 \sin[2\pi\lambda(\bar{x} - \bar{c}\bar{t})], \qquad \text{upper wall} \tag{1}$$

$\bar{h}_2(\bar{X}, \bar{t}) = -d' - a_2 \sin[2\pi\lambda(\bar{x} - \bar{c}\bar{t}) + \phi]$, lower wall (2)

We have $h_1(\bar{x}, \bar{t})$ and $h_2(\bar{x}, \bar{t})$ are the lower and upper walls, respectively, where (d, d′) represents the channel's width., (a_1, a_2) waves are amplified, (λ) is wave length,(c) is the velocity of the wave, and (ϕ) the speed of the waves ($0 \le \phi \le \pi$), then $\phi = 0$, is an out- of - phase channel that is symmetric, also $\phi = \pi$ waves are in phase, and of square-shaped coordinates is selected to that ($\bar{X}$ - axis) pointing in the wave's direction, and ($\bar{y}$- axis) is perpendicular to $\bar{X}$, with $\bar{t}$ representing the time.
Moreover, (d, d ′, $a_1 . a_2$ and ϕ) encounter next prerequisite.

$$a_1^2 + a_2^2 + 2\, a_1 a_2 \cos\phi \le (d + d')^2 \tag{3}$$

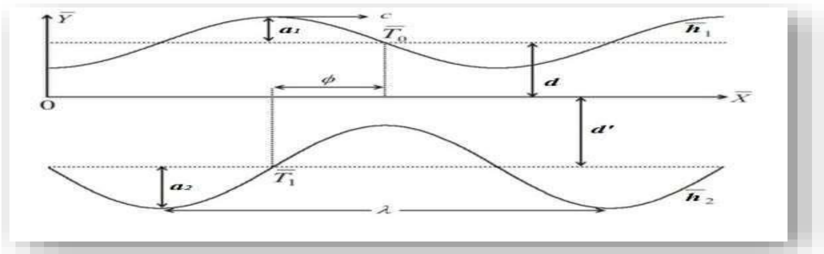

Figure 1: Using Cartesian asymmetry to compute channel coordinates in dimensional systems

3. Fundamental equation:

Model of Powell-Eyring obedient fluid's tensor T of Cauchy stress below (Hayat, Ali, et al., 2022) [12]

$$\bar{\mathcal{L}} = -\,\mathrm{p}\, \mathrm{I} + \bar{S}\,, \tag{4}$$

$$\bar{S} = [\,\mu + \frac{1}{\beta\gamma} \sinh^{-1}(\frac{\gamma}{C_1})]\, A_{11}\,, \tag{5}$$

$$\dot{\Upsilon} = \sqrt{\frac{1}{2} \mathrm{tras}\, (A_{11})^2}\,, \tag{6}$$

$$A_{11} = \nabla \bar{V} + (\nabla \bar{V})^{T}\,, \tag{7}$$

I

In the Powell - Eyring fluid, the material properties are represented by (β, C_1), the fluid pressure is denoted by p, the dynamic viscosity is (μ), the additional tension tensor is ($\bar{S}$) the identity tensor id (I), and the vector gradient is $\nabla = (\, d\bar{x}\,, d\bar{y}\,, 0)$, the term ($\sinh^{-1}$) is roughly similar to.

$$\sin h^{-1}(\frac{\Upsilon}{c_1}) = \frac{\Upsilon}{c_1} - \frac{\gamma^3}{6{c_1}^3}\,,\ |\frac{\gamma^5}{6c_1^5}| \ll 1\,, \tag{8}$$

4. Governing equation

There are three connected nonlinear momentum, energy, and continuity partial differentials expressed in a frame ($\bar{x}$, $\bar{y}$) control the flow..

$$\frac{d\bar{U}}{d\bar{X}} + \frac{d\bar{V}}{d\bar{Y}} = 0. \tag{9}$$

1. $\bar{X}$ - axis equation:

$$\rho(\frac{d\bar{U}}{d\bar{t}} + \bar{U}\frac{d\bar{U}}{d\bar{X}} + \bar{V}\frac{d\bar{U}}{d\bar{Y}}) - \rho\Omega(\Omega\bar{U} + 2\frac{d\bar{V}}{d\bar{t}}) - \frac{d\bar{P}}{d\bar{X}} + \frac{d\bar{S}_{\overline{XX}}}{d\bar{X}} + \frac{d\bar{S}_{\overline{XY}}}{d\bar{Y}} - \sigma B_0^2\bar{U} - \frac{\mu}{k}\bar{U} + g\rho B_T(T - T_0) + g\rho B_c(C - C_0). \tag{10}$$

2. $\bar{Y}$ - axis equation:

$$\rho(\frac{d\bar{V}}{d\bar{t}}+\bar{U}\frac{d\bar{V}}{d\bar{X}}+\bar{V}\frac{d\bar{V}}{d\bar{Y}})-\rho\,\Omega\,(\Omega\bar{U}+2\frac{dv}{d\bar{t}})=-\frac{d\bar{P}}{d\bar{Y}}+\frac{d\bar{S}_{\bar{X}\bar{Y}}}{d\bar{X}}+\frac{d\bar{S}_{YY}}{d\bar{Y}}-\sigma B_0^2\bar{V}-\frac{\mu}{\bar{K}}\bar{V}. \tag{11}$$

3. Energy equation:

$$\rho c_p(\frac{c}{\lambda}\frac{d}{dt}+\frac{c}{\lambda}u\frac{d}{dx}+\frac{\delta c}{d}v\frac{d}{dy})(T - T_0) = k\,(\frac{c^2}{\lambda^2}+\frac{d^2}{dt^2}+\frac{1}{\lambda^2}\frac{d^2}{x^2}+\frac{1}{d^2}\frac{d^2}{dy^2})(T- T_0)+\theta. \tag{12}$$

4. Concentration equation:

$$\frac{dc}{dt}=D\frac{d^2c}{dy^2}+kr(c-c_0)+\frac{Dk_T d^2\,T}{T_m dy^2} \tag{13}$$

Where (ρ) know the density of the liquid, $\bar{\mathcal{V}}$ velocity vector and ($\bar{P}$) represents the Pressure, ($\bar{S}_{\bar{X}\bar{X}}$, $\bar{S}_{\bar{X}\bar{Y}}$, $\bar{S}_{\bar{Y}\bar{Y}}$) the stress tensor's components of $\bar{S}$, (σ) is an electrical conductor. (B_0) is the magnetic field that remains constant, (Ω) represents the rotation, (C_p) is specifically heated, (k) is the thermal conductivity, (T) is the temperature, (μ) It represents viscosity, elements of Powell-Eyring additional stress tensor are listed below, according to definitions provided by Equation (5)

$$\bar{S}_{\bar{X}\bar{X}}=2\,(\mu+\frac{1}{\beta C_1})\,\bar{U}_{\bar{x}}-\frac{1}{3\beta C_1^3}\,[2\,\bar{U}_{\bar{x}}^2+(\bar{U}_{\bar{y}}+\bar{V}_{\bar{x}})^2+2\bar{V}_{\bar{y}}^2]\,\bar{U}_{\bar{x}}\,. \tag{14}$$

$$\bar{S}_{\overline{XY}}=(\mu+\frac{1}{\beta C_1})\,(\bar{U}_{\bar{y}}+\bar{V}_{\bar{x}})-\frac{1}{6\beta\,C_1^3}\,[2\bar{U}_{\bar{x}}^2+(\bar{U}_{\bar{y}}+\bar{V}_{\bar{x}})^2+2\bar{V}_{\bar{y}}^2]\,(\bar{U}_{\bar{y}}+\bar{V}_{\bar{x}})\;. \tag{15}$$

$$\bar{S}_{\overline{YY}}=2\,(\mu+\frac{1}{\beta C_1})\,\bar{V}_{\bar{y}}-\frac{1}{\beta\,C_1^3}\,[\bar{U}_{\bar{x}}^2+(\bar{U}_{\bar{y}}+\bar{V}_{\bar{x}})^2+2\bar{V}_{\bar{y}}^2\,]\,\bar{V}_{\bar{y}}\,. \tag{16}$$

While peristaltic motion in its natural state is unpredictable, it can be stabilized by applying the transformation from the laboratory framework ($\bar{X}$, $\bar{y}$), toward the wave frame ($\bar{x}$,$\bar{y}$). The changes that followed establish the connection between. pressure and coordinate velocity within the frame of the lab ($\bar{X}$, $\bar{Y}$), the wave frame as well ($\bar{x}$, $\bar{y}$).

$$\bar{X}=\bar{x}-c\bar{t}\,,\;\bar{Y}=\bar{y},\;\;\bar{u}=\bar{U}-c,\;\bar{V}=\bar{v},\;\bar{p}\,(\bar{x},\bar{y})=\bar{P}(\bar{X}\,,\,\bar{Y}\,,\,\bar{t}) \tag{17}$$

wherever $\bar{U}$ and $\bar{V}$ indicate the speed $\bar{p}$ is a symbol for the pressure inside the wave frame. Now, we swap out Equation (17) into formulas (1) (2) and (9-16) and add the non – dimensional variables to the final equation to normalize it.

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$$x=\frac{1}{\lambda}\bar{X},\quad y=\frac{1}{d}\bar{Y},\quad U=\frac{1}{c}\bar{U},\quad V=\frac{1}{\delta c}\bar{V},\quad p=\frac{d^2}{\lambda\mu c}\bar{p},\quad t=\frac{c}{\lambda}\bar{t},\quad h_1=\frac{1}{d}\bar{h}_1,\quad h_2=\frac{1}{d}h_2$$

$$\delta=\frac{d}{\lambda},\quad Re=\frac{\rho cd}{\mu},\quad Ha=d\sqrt{\frac{\sigma}{\mu}}\,\beta_0,\quad Da=\frac{k}{d^2},\quad w=\frac{1}{\mu\beta c_1},\quad A=\frac{w}{6}\,(\frac{c}{dc_1})^2,\quad T=T-T_0$$

$$\theta=\frac{T-T_0}{T_1-T_0},\quad S_{xx}=\frac{\lambda}{\mu c}\bar{S}_{\overline{xx}},\quad S_{xy}=\frac{d}{\mu c}\bar{S}_{\overline{xy}},\quad S_{yy}=\frac{d}{\mu c}\bar{S}_{\overline{yy}},\quad Gr=\frac{\rho g B_T\,d^2(T-T_0)}{Mc}$$

$$Gc=\frac{\rho g B_c d^2(c-c_0)}{\mu c},\quad \emptyset=\frac{(\boldsymbol{c}-\boldsymbol{c_0})}{(\boldsymbol{c}-\boldsymbol{c_0})},\quad \theta=\frac{(T-T_0)}{(T_1-T_0)},\quad Sc=\frac{dc}{D},\quad Sr=\frac{Dk_T(\,T_1-T_0)}{CT_m\,d(\,C_1-C_0)}, \tag{18}$$

where non-dimensional lower and upper wall surfaces are denoted by (h_1) and (h_2) respectively, and (δ)is the wave number. The variables that represent the composition of the system are (Re)for Reynolds number, (Ha)for Hartman number,(∅) for ratio of amplitude,(w) the Darcy number (Da) and Powell-Eyring liquid, and (A) represent the porous material's non-dimensional permeability media, respectively. The (T_0) and (T_1) for temperatures at both are

top or bottom, (Gr) is thermal Grashof number, and (Gc) for solutes Grashof number, (Sc) represents the Schmidt number, (Sr) and is the amount of sores, and (θ) dimensionless temperature.
Now substitute Equations (17) and (18) into Equations (1), (2) and (14 -16) and normalize the resulting equation with the following non-dimensional variables:

Equation (1) becomes:

$$h_1(x, t) = 1 - \bar{a}\sin(2\pi x)\,, \tag{19}$$

this now becomes formula (2).

$$h_2(x, t) = -d^* - b\sin(2\pi x + \emptyset), \tag{20}$$

then, we have [$\bar{a}$, b, d* also $\emptyset$] substitute it into Equation (3)

$$\bar{a}^2 + b^2 + 2\,\bar{a}b\cos\phi \le (1 + d^*)^2\,, \tag{21}$$

$$\frac{du}{dx} + \frac{dv}{dy} = 0\,, \tag{22}$$

$$\mathrm{Re}\delta\left(\frac{du}{dt} + u\frac{du}{dx} + v\frac{du}{dy}\right) - \frac{\rho d^2\Omega}{\mu}\left(\Omega u + 2\frac{\delta c}{\lambda}\frac{dv}{dt}\right) = -\frac{dp}{dx} + \delta^2\frac{d}{dx}S_{xx} + \frac{d}{dy}S_{xy} - H\bar{\alpha}^2 u - \frac{1}{Da}u + Gr\,\theta + Gc\emptyset, \tag{23}$$

$$\mathrm{Re}\delta^3\left(\frac{dv}{dt} + u\frac{dv}{dx} + v\frac{dv}{dy}\right) - \frac{\rho d^2\Omega\delta}{\mu}\left(\Omega v + 2\frac{\delta c}{\lambda}\frac{dv}{dt}\right) = -\frac{dp}{dy} + \delta^2\frac{ds_{xy}}{dx} + \delta\frac{ds_{yy}}{dy} + Ha^2 v\delta - \frac{\delta^2}{Da}v, \tag{24}$$

$$\mathrm{Re}\,\rho r\,\delta\left(\frac{d}{dt} + \delta u\frac{d}{dx} - \delta v\frac{d}{dy}\right)\theta = \left(\delta^2\frac{c^2d^2}{dt^2} + \delta^2\frac{d^2}{dx^2} + \frac{d^2}{dy^2}\right) + B\,, \tag{25}$$

$$\rho c_p\delta\left(\frac{d}{dt} + u\frac{d}{dx} + v\frac{d}{dy}\right)\left(\frac{(c - c_0)}{(c_1 - c_0)}\right) = \frac{d}{c}\frac{D}{(c - c_0)}\frac{d^2c}{dy^2} - kr\frac{(c - c_0)}{(c - c_0)} + \frac{d}{c}\frac{Dk_Td^2T}{(C - C_0)T_m dy^2}, \tag{26}$$

$$S_{xx} = 2(1 + w)\frac{du}{dx} - 2A\left[2\delta^2\left(\frac{du}{dx}\right)^2 + \left(\frac{du}{dy} + \delta^2\frac{dv}{dx}\right)^2 + 2\delta^2\left(\frac{dv}{dy}\right)^2\right]\frac{du}{dx}\,, \tag{27}$$

$$S_{xy} = (1 + w)\left(\delta^2\frac{dv}{dx} + \frac{du}{dy}\right) - A\left[2\delta^2\left(\frac{du}{dx}\right)^2 + \left(\frac{du}{dy} + \delta^2\frac{dv}{dx}\right)^2 + 2\delta^2\left(\frac{dv}{dy}\right)^2\right]\left(\delta^2\frac{dv}{dx} + \frac{du}{dx}\right), \tag{28}$$

$$S_{yy} = 2(1 + w)\,\delta\frac{dv}{dy} - 2A\delta\left[2\delta^2\left(\frac{du}{dx}\right)^2 + \left(\frac{du}{dy} + \delta^2\frac{dv}{dx}\right)^2 + 2\delta^2\left(\frac{dv}{dy}\right)^2\right]\frac{dv}{dy}, \tag{29}$$

we note the relation between, the function of the stream, (ψ), and the velocity component:

$$u = \frac{d\Psi}{dy} \quad v = -\frac{d\Psi}{dx}\,. \tag{30}$$

We substitute Equation (30), into Equation (23)- (29), keeping in mind that the mass balance shown by Equations, (22), is also satisfied, which results in the satisfaction of Equation (30).

$$\mathrm{Re}\delta\left(-\frac{d^2\Psi}{dtdy} + \frac{d^3\Psi}{dxdy^2} - \frac{d^3\Psi}{dxdy^2}\right) - \frac{\rho d^2\Omega}{\mu}\left(\Omega\frac{d\Psi}{dy} - 2\frac{\delta c}{\lambda}\frac{d^2\Psi}{dtdx}\right) = -\frac{dp}{dx} + \delta^2\frac{d}{dx}S_{xx} + \frac{d}{dy}S_{xy} - Ha^2\frac{d\Psi}{dy} - \frac{1}{Da}\frac{d\Psi}{dy} + Gr\,\theta + Gc\,\emptyset, \tag{31}$$

$$\mathrm{Re}\,\delta^3\left(\frac{d^2\Psi}{dtdx} + \frac{d^3\Psi}{dx^2dy} + \frac{d^3\Psi}{dx^2dy}\right) - \frac{\delta\rho\Omega d^2}{\mu}\left(\Omega\frac{d\Psi}{dx} - 2\frac{\delta c}{\lambda}\frac{d^2\Psi}{dtdx}\right) = \frac{dp}{dy} + \delta^2\frac{ds_{xy}}{dx} + \delta\frac{ds_{yy}}{dy} + Ha^2\frac{d\Psi}{dx}\delta + \delta^2\frac{1}{Da}\frac{d\Psi}{dx}, \tag{32}$$

$$\mathrm{Re}\,\rho r\,\delta\left(\frac{d}{dt} + \Psi_y\frac{d}{dx} - \Psi_x\frac{d}{dy}\right)\theta = \left(\delta^2\frac{c^2d^2}{dt^2} + \delta^2\frac{d^2}{dx^2} + \frac{d^2}{dy^2}\right)\theta + B, \tag{33}$$

$$\rho c_p\delta\left(\frac{d}{dt} + \Psi_Y\frac{d}{dx} - \Psi_X\frac{d}{dy}\right)\left(\frac{(c - c_0)}{(c_1 - c_0)}\right) = \frac{d}{c}\frac{D}{(c - c_0)}\frac{d^2c}{dy^2}kr\frac{(c - c_0)}{(c - c_0)} + \frac{d}{c}\frac{Dk_Td^2T}{(C - C_0)T_m dy^2}, \tag{34}$$

$$S_{xx} = 2(1 + w)\frac{d^2\Psi}{dxdy} - 2A\left[2\delta^2\left(\frac{d^2\Psi}{dxdy}\right)^2 + \left(\frac{d^2\Psi}{dy^2} - \delta^2\frac{d^2\Psi}{dx^2}\right)^2 + 2\delta^2\left(-\frac{d^2\Psi}{dxdy}\right)^2\right]\left(\frac{d^2\Psi}{dxdy}\right), \tag{35}$$

$$S_{xy} = (1+w)(- \delta^2 \frac{d^2\Psi}{dx^2}\frac{d^2\Psi}{dy^2} -A[2\delta^2 (\frac{d^2\Psi}{dxdy})^2 +(\delta^2 \frac{d^2\Psi}{dx^2}+ \delta^2 \frac{d\Psi}{dy^2})^2 + 2\delta^2(\frac{d^2\Psi}{dxdy})^2] (\delta^2 \frac{d^2\Psi}{dx^2} \frac{d^2\Psi}{dy^2}), \tag{36}$$

$$S_{yy}= -2(1+w)\delta \frac{d^2\Psi}{dxd} - 2A\delta [2\delta^2(\frac{d^2\Psi}{dxdy})^2 + (\frac{d^2\Psi}{dy^2} - \delta^2 \frac{d^2\Psi}{dx^2})^2 + 2\delta^2(\frac{d^2\Psi}{dxdy})^2] \left(-\frac{d^2\Psi}{dxdy}\right), \tag{37}$$

the formulas from (31) to (36) is form ($Re\ and\ \delta \ll 1$) are present:

$$0 = - \frac{dP}{dx} + \frac{dS_{xy}}{dy} - (Ha^2 - \frac{1}{Da})\, \varphi_y + G_r\theta + G_c\emptyset, \tag{38}$$

$$-\frac{dp}{dy} = 0, \tag{39}$$

while the additional stress tensor's component takes on the shape of

$$S_{XX} = 2\,(1+w) \frac{d^2\Psi}{dxdy} - 2A\,(\frac{d^2\Psi}{dy^2}) \frac{d^2\Psi}{dxdy}\ , \tag{40}$$

$$S_{XY} = (1 + w)(\frac{d^2\Psi}{dy^2}) - A\,(\frac{d^2\Psi}{dy^2})^3\ , \tag{41}$$

$$S_{yy} = 0, \tag{42}$$

The following equation is found if Equation (41) is used as a stand-in the Equation (38) and the derivation using respect to y via (w + 1) calculated:

$$\frac{d^4\Psi}{dy^4} - \eta\, A \frac{d^2}{dy^2}(\frac{d^2\Psi}{dy^2})^3 - \eta\, \zeta\, \frac{d\Psi}{dy} + \eta\, Gr\, \theta + \eta\, G\, c\, \emptyset = 0, \tag{43}$$

$$\boldsymbol{\zeta} = \frac{\boldsymbol{Ha^2\, u + \frac{1}{Da} \frac{\rho d^2 \Omega^2}{\mu}}}{\boldsymbol{w+1}}\ , \qquad \boldsymbol{\eta} = \frac{\boldsymbol{1}}{\boldsymbol{w+1}},$$

the dimensionless volume flow rate and boundary condition in the wave frame are as follows:

$$\Psi = \frac{F}{2}\ , \frac{d\Psi}{dy} = -1\ \ , \theta = 0 \ \text{ at } \ Y = h_1\, , \tag{44}$$

$$\Psi = -\frac{F}{2}\ , \frac{d\Psi}{dy} = -1\ \ , \theta = 0 \ \text{ at } \ Y = h_2\, , \tag{45}$$

The initial letter F, represents the dimensionless temporal average in the wave frame.

5. The problem's solution:

Through increasing in flow rates in a power series A, the perturbation method is utilized to solve a non-linear partial differential equation system

$$\Psi = \Psi_0 + A\, \Psi_1 + 0\ (A^2)\, , \tag{46}$$

$$p = p_0 + A\, p_1 + 0\ (A^2)\, , \tag{47}$$

Now, by substituting Equations (48) and (49), with boundary condition (48) and (49), and comparing the coefficients of the same A power up the first order yields the two- system solution listed below:

6. Systems of zeroth order:

If the zeroth order system's criteria for the order are Rn, which are negligible, we obtain:

$$\Psi_{0yyyy} - \zeta\, \Psi_{1yy} = 0, \tag{48}$$

$$\Psi_0 = \frac{F_0}{2}\ \ .\ \ \frac{d\Psi_0}{dy} = -1 \ \text{ at } \ Y = h_1, \tag{49}$$

$$\Psi_0 = -\frac{F_0}{2} \quad . \quad \frac{d\Psi_0}{dy} = -1 \quad \text{at} \quad Y = h_2, \tag{50}$$

7. First order system:

$$\Psi_{1yyy} - \eta \frac{d^2}{dy^2}(\Psi_{0yy})^3 - \zeta \Psi_{1yy} = 0, \tag{51}$$

$$[\ \Psi_{1yyyy} - \zeta\Psi_{1yy} = \eta \frac{d^2}{dy^2}(\Psi_{0yy})^3\ ], \tag{52}$$

$$\Psi_1 = \frac{F_1}{2}\ , \quad \frac{d\Psi_1}{dy} = 0 \quad . \quad \text{at} \quad Y = h_1, \tag{53}$$

$$\Psi_1 = \frac{F_1}{2}\ , \quad \frac{d\Psi_1}{dy} = 0\ . \quad \text{at} \quad Y = h_2, \tag{54}$$

you can obtain the last equation for by resolving the zero-order as well as first-order system the function of the stream.

$\Psi = \Psi_0 + A\Psi,$

$u(x, y, t) = \Psi_y$

8. Results and discussions:

In this section we look a velocity which is covered in the first section and the, (MATHEMATICA) program was used to study the pressure gradient in the second section.

8.1. Velocity distribution

The axial velocity across the channel is varied as it is indicated by the case variation of u. The effect of different values [Ha, Da, β, Ω, kr, B, Gc, Gr, Sc, Sr]. On the axial velocity u is shown in Figures (2) - (11). where the behavior of the velocity distribution is parabolic as shown in the following figures:

a- Figures (2), (3), (4) show that the axial velocity increases with the increase of Hartmann number (Ha), Darcy number (Da) and magnetic field inclination (β) in the central region of the channel, while it is not affected at the channel wall.

b- In Figures (5), (6), (7), (8), (9), (10), and (11), we notice that the values of rotation (Ω) are increase, and each of the values of the parameters [kr, B, Gr, Gc, Sr, Sc], that the axial speed is decrease in the middle of the channel and is not affected at the walls.

8.2. Pressure gradient (dp/dx)

Relevant pressure gradient parameters effects (dp/dx) will be visually depicted in Figures (12) - (21)

a- In Figures [(12), (14), (15), (16), (17), (18), (19), and (21), we notice that when the values of Hartmann number (Ha), Darcy number (Da), rotation (Ω), and parameters [(B), (kr), (Gc) (Gr), (Sc)]. are increased, as well as the axial pressure gradient increases in the middle of the channel towards the top of the curve, but no change occurs in the axial pressure gradient in the left or right perimeter of the channel.

b- In Figures (13) and (20), when increasing each of the values of the magnetic field (β), and the values of the parameter (Sr), we notice that the axial pressure gradient decreases in the middle region of the channel and is not affected at the walls.

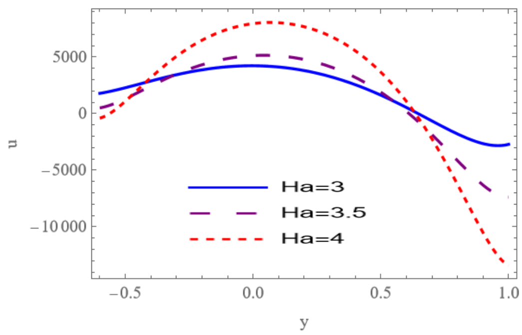


Figure 2: Change in velocity in relation to (Ha) values when β=1,Da=6,Ω=0.3, kr=0.5, Gc=0.8,B=0.1,Gr=1.8,Sc=0.8,Sr=1.8.

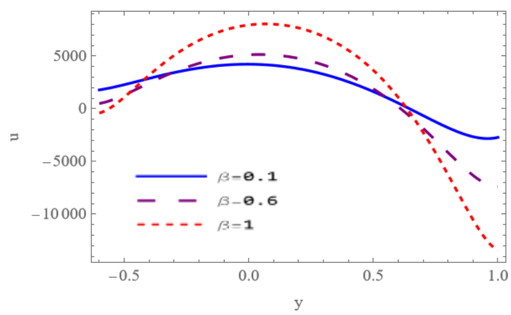


Figure 3: Change in velocity in relation to (β) values when Ha=3,Da=6,Ω=0.3,kr=0.5,B=0.1 Gc=0.8, Gr=1.8, Sc=0.8,Sr=1.8.

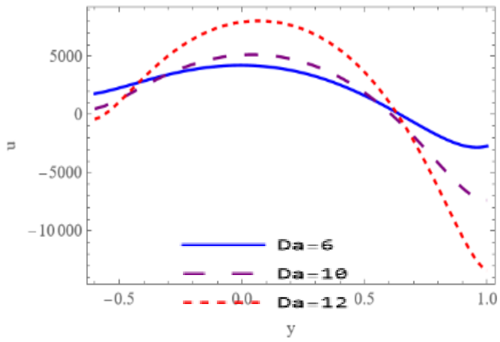


Figure 4: Change in velocity in relation to (Da)values when Ha=3,*β*=1,B=0.1,Ω=0.3, kr=0.5,Gc=0.8,Gr=1.8,Sc=0.8,Sr=1.8.

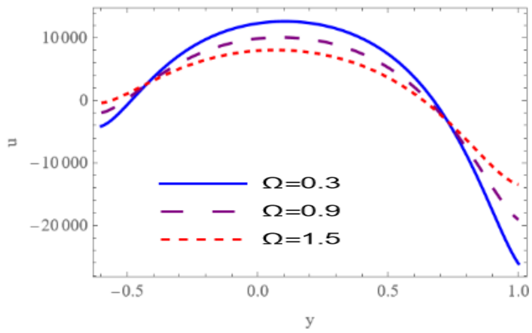


Figure 5: variation of velocity in to relation (Ω) values when Ha=3,kr=0.3, B=0.1,Da=6, Gc=0.8, β=0.1,Gr=1.8,Sc=0.8,Sr=1.8.

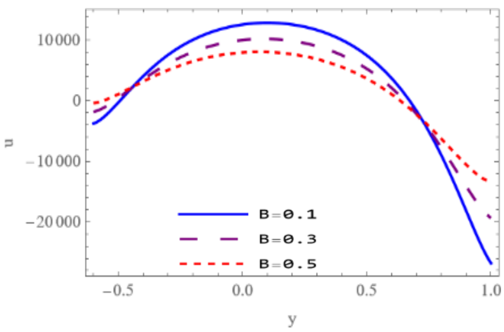


Figure 6: Change in velocity in relation to (B) values when, Ha=3, β=1,Da=6,kr=0.3 Ω=0.3,Gc=0.8,Gr=1.8,Sc=0.8,Sr=1.8.

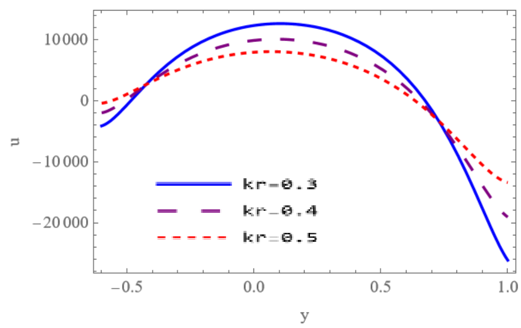


Figure 7: Change in velocity in relation to (kr)values when, Ha=3, β=1,Da=6,Ω=0.3 B=0.1,Gc=0.8,Gr=1.8,Sc=0.8,Sr=1.8,

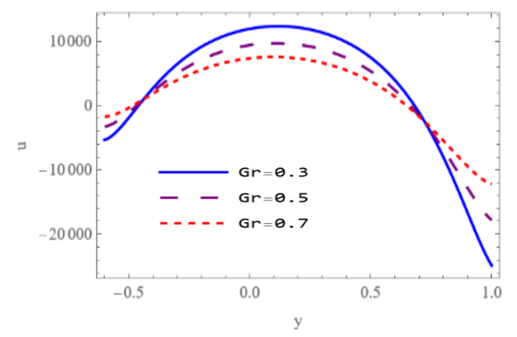


Figure 8: Change in velocity in relation to (Gr) values when, Ha=3,B=0.1,Da=1 β=1,Ω=0.3,kr=0.5, Gc=0.8,Sc=1.8,Sr=1.8.

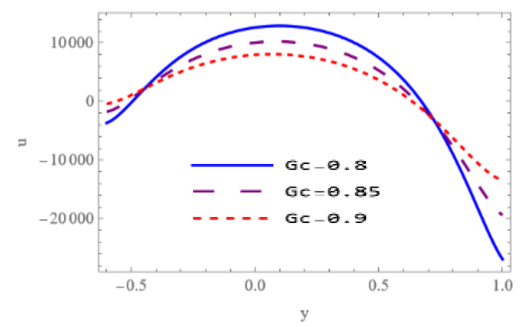
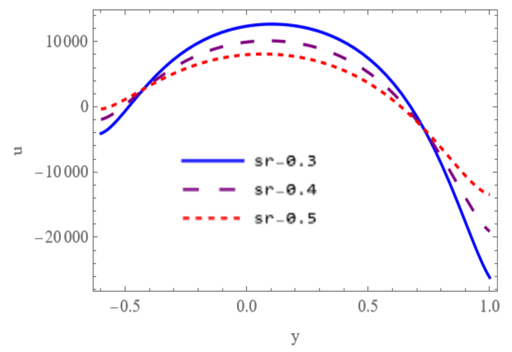
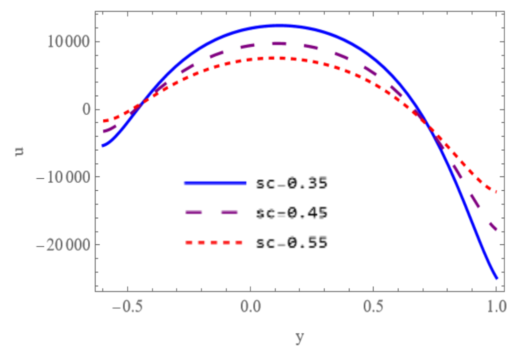


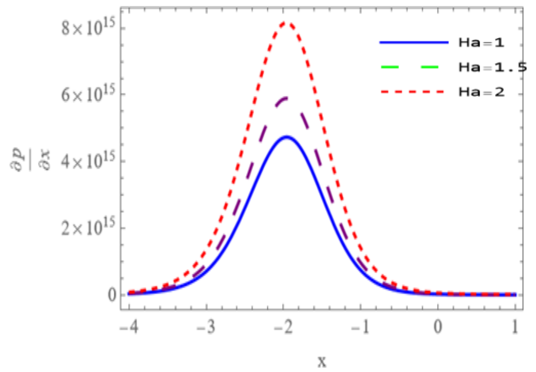
Figure 9: Change in velocity in relation to (Gc)values when, Ha=3,Da=1,B=0.1 β=1,Ω=0.3,kr=0.5,Gr=1.8,Sc=0.8,Sr=1.8.



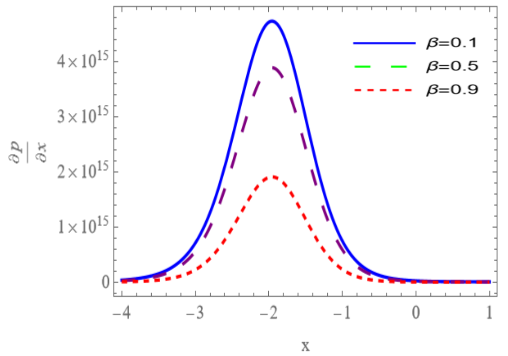
Figure(10): variation of velocity in relation to (Sr) values when, Ha=3, β =1,Da=6,Ω=0.3 kr=0.5,B=0.1,Gc=0.8 ,Gr=1.8,Sc=0.8.



Figure(11): variation of velocity relation to (Sc)values when, Ha=3, β =1 Da=6, Ω= 0.3,B=0.1 kr=0.5,Gc=0.8,Gr=1.8, Sr=1.8.



Figure(12): Change in the pressure gradient for different amounts of (Ha) when B=0.1,Da=6 β =1, Ω =0.3,kr=0.5,Gc=0.8,Gr=1.8, Sc=0.8,Sr=1.8.



Figure(13): Change in the pressure gradient for different amounts of (β) when Ha=3,B=0.1,Da=6 Ω=0.3,kr=0.5,Gc=0.8,Gr=1.8,Sc=0.8,Sr=1.8.

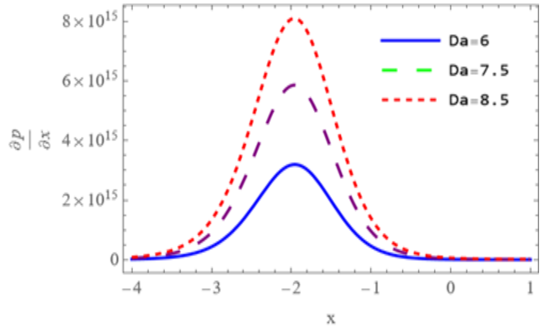


Figure 14:changes in the pressure gradient different amounts of (Da.) when Ha=3, β =1,B=0.1 Ω=0.3,kr=0.5,Gc=0.8,Gr=1.8,Sc=0.8,Sr=1.8.

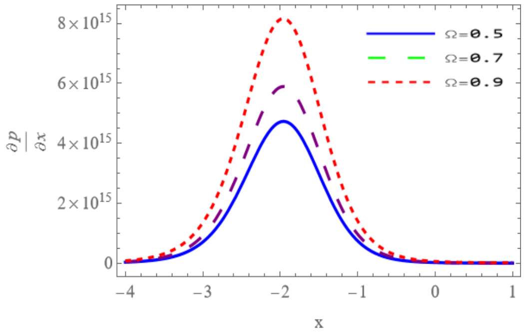


Figure 15: Changes in the pressure gradient for different amounts of (Ω)when Ha=3, β = 1,Da=6 B=0.1, kr=0.5,Gc=0.8,Gr=1.8,Sc=0.8,Sr=1.8.

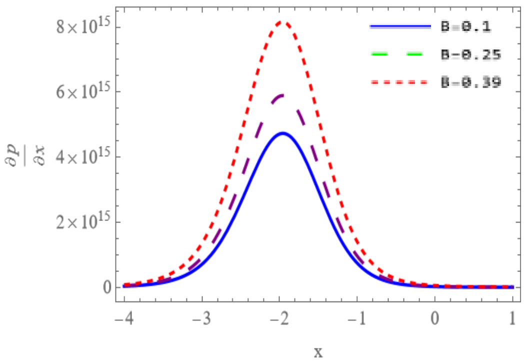


Figure 16:Changes in the pressure gradient for different amounts of (B) when Ha=3, Da=6 β =1,Ω=3,kr=0.5,Gc=0.8,Sc=0.8,Gr=1.8 , Sr=1.8.

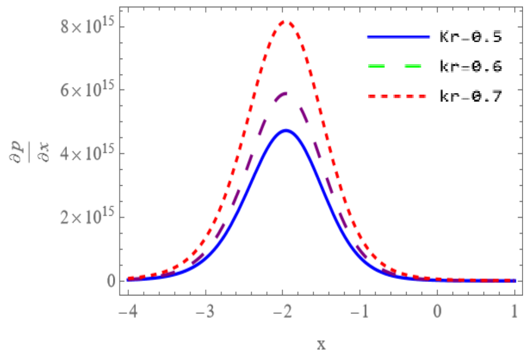


Figure 17: Changes in the pressure gradient for different amounts of (kr) when Ha=3,Da=6, β =1,Ω=0.3,B=0.1,Gc=0.8,Gr=1.8,Sc=0.8, Sr=1.8

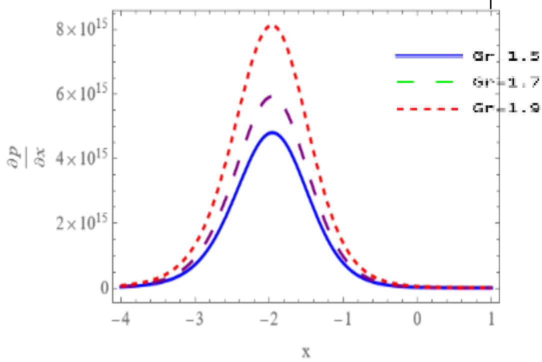


Figure 18: Changes in the pressure gradient for different amounts of (Gr) when Ha=3,Da=6,B=1 β =1,Ω=0.3,kr=0.5, Gc=0.8, Sc=0.8,Sr=1.8.

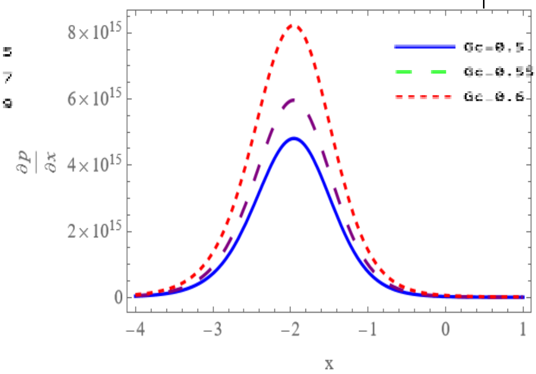


Figure 19: Changes in the pressure gradient for different amounts of (Gc) when Ha=3,Da=6, β =1,Ω=0.3,B=0.1,kr=0.5,Gr=1.8,Sc=0.8,Sr=1.8.

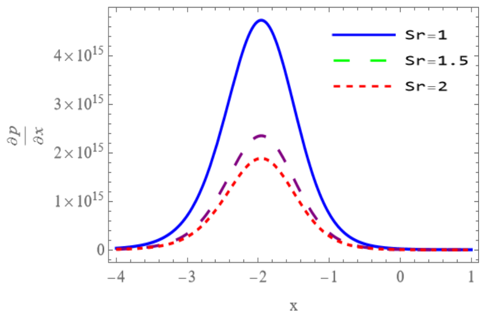


Figure (20): Changes in the pressure gradient for different amounts of (Sr) when Ha=3,B=0.1, β =1,Da=6,kr=0.5,Gc=0.8 Ω=0.3Gr=1.8,Sc=1.8.

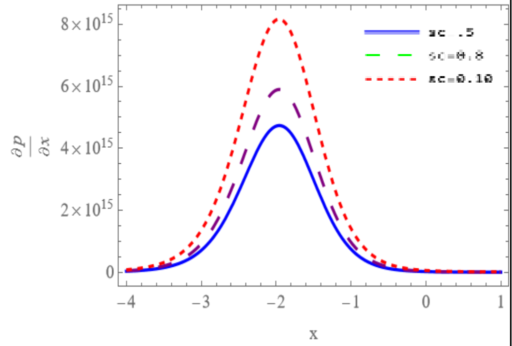


Figure (21): Changes in the pressure gradient for different amounts of (Sc) when Ha=3 β =1,Da=6, Ω=0.3,kr=0.5,B=0.1,Gc=0.8, Gr=1.8 , Sr=1.8.

9. Conclusions:

This chapter will look at the spinning effects of Powell-Eyring fluid peristaltic flow through a porous medium that is simultaneously affected by a straight line (MHD) magnetic field created by selecting low Reynolds number peristaltic waves with varying amplitudes and phases over uneven walls. Then, using the turbulence approach-where the axial velocity and pressure gradient formulas are given-we examine the parameters using a number of graphs. This work investigates the effects of rotation on the peristaltic transport of a Powell-Eyring fluid in a symmetric channel during fluid movement in a porous medium that is susceptible to both the (MHD) magnetic field and the unified effects of fluid movement. It is believed that this field of research is concerned with. Investigating the impact of magnetic fields on fluid flow.

a- The axial velocity increases with the increase of the Hartmann number (Ha), the magnetic field slope (β) and the Darcy number (Da) in the middle of the channel and decreases in the region of the side walls of the channel.
b- It is noted that the middle of the channel is subjected to a decrease in the axial velocity for all values of rotation (Ω), parameter values (P), thermal Grasshof number (Gr), solute Grasshof number (Gc), coefficient (B), Schmidt number (Sc), and Soret number (SR), and the axial velocity at the channel walls is not affected.
c- We notice when increasing the values of Hartmann number (Ha), Darcy number (Da), rotation (Ω), and the parameters [(B), (kr), (Gc) (Gr), (Sc)], the pressure gradient increases in the middle of the channel towards the top of the curve, but there is no change in the axial pressure gradient on the left or right channel walls.
d- We notice when increasing both the values of the magnetic field (β), and the values of the parameter (Sar). We notice that the axial pressure gradient decreases in the middle region of the channel and is not affected at the walls.

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