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CASSON FLOW OF BLOOD CONTAINING Au AND Ta NANOPARTICLES OVER A STENOTIC ARTERY

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Computational fluid dynamics focuses a premium on investigations of blood flow via narrowed arteries due to the relevance of these issues to biological investigations. The main goal of this study is to find out how nanoparticles affect blood flow via a constricted artery. As part of our investigation into the theoretical flow scenario, we examine the significance of Casson nanofluid movement via a cardiac artery. By using the suitable delf similarity variables the PDEs transformed into ODEs. Following that, the dimensionless equations are handled employing the MATLAB computer program in the Bvp5c method. The magnetic properties of the blood flow cells were investigated by increasing the magnetic field parameter, which resulted in a reduction in blood flow as predicted. The movement trend reduced when the Casson liquid parameter increased. To improve the transmission of heat efficiency, the concentration of gold particles in the constricted artery should be increased. One may argue that iron nanoparticles are useful for delivering medications. Presently available methods may be useful for distributing drugs throughout the circulatory system. The theoretical consequences of this medication delivery method are presented in a manner that is made easier by the utilization of an illustration representation.
Keywords: *Au and Ta nanoparticles; Bvp5c method; Stenotic artery; MHD; Casson fluid*
PACS: 44.05.+e, 44.30.+v, 44.40.+a, 47.10.ad., 52.75.Fk.

1. INTRODUCTION

The arteries are becoming more blocked as a result of contemporary lifestyle behaviours such as smoking, raised cholesterol levels, and, maybe, inherited problems. The strengthening and constriction of the artery walls is a particularly prevalent ailment in the circulatory system. This condition is called coronary artery stenosis in healthcare research. Arteries with stenosis have narrowed or constricted on the inside, reducing the amount of blood along with other fluids that may reach other parts of the body. The way blood moves through arterial stenosis is an extremely significant subject to talk about when trying learn about circulation illnesses, since numerous of individuals are caused by problems with the way blood vessels are built and how blood moves through them [1]. The human heart serves as the foundational organ of a creature's circulatory system, which distributes oxygen-enriched blood via capillaries to various body regions. Therefore, a healthy life cycle depends on the heart's normal and active operation. Arterial and circulatory issues, however, have emerged as a single of the harmful illnesses causing a growing number of fatalities globally in the past few decades. The majority of these illnesses are related to the unique and aberrant flow of blood via arteries. Many medical professionals and creative thinkers have proposed theories as to why blood circulation via arteries is restricted. The most common reason for abnormal circulatory function among such methods is the formation of atheromatous plaque within vessels. Numerous doctors and imaginative individuals have developed hypotheses to explain the reason blood flow through veins is limited. The most prevalent cause of diminished cardiovascular performance across these techniques is the creation of atheromatous stones inside arteries. From a health perspective, doctors have indicated that this condition may be healed in its initial phases, yet as plaque growth gathers, it inhibits blood flow to various vascular/cardiovascular parts of the human body, potentially resulting in an exacerbated cardiac event [2]. Overall, the presence of stenotic arterial walls that contain such tiny particles might boost the appearance of limited or obstructed blood flow, aiding in assessment and therapy planning, as well as the relevance of particles in atherosclerosis as shown in Figure 1.

Figure 1. The use of particles in the therapy of cardiovascular diseases

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The improvement of the occurrence of heat transportation represents a significant contribution to the procedures that are used in technological and manufacturing applications. It is well noticed that advancements in renewable energy sources have been made using various base fluids. However, since these fundamental elements have a smaller thermal effect, the heating process takes longer. Thus, a revolutionary strategy for enhancing heat transmission in fluids is to include particles within the fundamental fluid, resulting in a nanofluid together Choi and Eastman [3]. Nanofluids offer much higher heat conductivity compared standard fluids. As a consequence, nanoparticles have been considered for a range of uses, such cooling nuclear power plants, reducing cars and equipment, freezing electrical appliances, and biomedical [4][5]. Many individuals have investigated the behavior of tiny fluids and the qualities that they possess in a variety of various manners as a result of approach. The relevance of tiny material volume proportion in relation to nanofluid dispersion was first brought to light by Tiwari and Das [6], who added to the discussion. The nanoparticles have great potential for improving disease detection and therapy precision. Nanotechnology, via cell-specific focusing on, transport of molecules to particular organelle components, and additional techniques, could assist to circumvent the constraints of traditional delivery, ranging from massive amounts challenges like biological distribution to smaller-scale obstacles like intracellular movement. To help with understand and clinical implementation of such potential nano-enabled innovations, the US National Sciences and Technology Council (NSTC) established the National Nanotechnology Initiative (NNI) in 2000, which detailed clear priorities and major obstacles for the area. These programs have endorsed contemporary attempts to examine and develop nanotechnology, with nanoparticles (NPs) accounting for a large amount of published investigation and improvement [7][8]. Several initial NP versions failed to conquer biological transport hurdles, while current NP models have used advances in regulated manufacturing procedures to add complex topologies, bio-responsive components, and targeting substances to improve delivery [9][10][11][12][13][14].

The nano-drug delivery improves the stenosis throat's clotting formation; further, this computational simulation can also predict the effects of post-treatment processes. It is witnessed from the literature that several studies [21], [22], [23], [24], explore the blood flow in different types of stenosis arteries with numerous physical aspects.

The current study was motivated by the actual usefulness of nano-drug transport techniques. The procedure regarding selecting the best therapy for coronary artery blockage constitutes a big part of this computer exercise. Computational blood flow modeling has a lot of potential to help people make decisions about how to treat circulatory illnesses. Usually, narrowing is addressed through placing tubes or devices within the stenotic artery. However, nano-drugs are being delivered more and more specifically to particular areas. Additionally, this method starts the creation of blood blockages at the blocked region within the arterial system, and computer models can be used to guess what effect these reactions will have after treatment. Various shaped, sized, along with additional features of stenosis vessels have been studied in numerous additional investigations, as demonstrated by the example mentioned above. According to the best of the author knowledge there is no research has been done on heat transfer analysis on Casson nanofluid over a stenotic artery in the presence of magnetohydrodynamics. Additional uses utilizing gold-tantalum tiny particles contain the administration of medications, tumor diagnostics, heart disease medication, and immunotherapy. Based on the above the mathematical flow equations are in terms of PDEs. With the help of similarity variables to convert the PDEs to ODEs, after that we used Bvp5c technique in MATLAB solver. Higher values of the magnetic field parameter increased velocity profile.

Heart disease-related health issues and fatalities impact a large proportion of the worldwide community. Additionally, there is no unanimity concerning how to fix these medical problems, including among medical professionals and researchers. One prevalent cardiovascular condition which may result in stenosis a narrowing of the arteries and reduced blood circulation is coronary artery disease or the accumulation of cholesterol in the artery walls. This research intends to discover the number of factors that influence the manner in which something particular moves via a blood vessel, which is a smaller segment of human body. Issues that excite interest among individuals in fluids include how they move around, the biological activities that take place inside them, and how fast the liquid moves.

2. MATHEMATICAL FORMULATION OF THE PROBLEM

- In this particular research framework, we made the assumption that the stable two-dimensional Casson fluid flow model across a stenosed artery is incompressible. Additionally, we investigated magnetohydrodynamics.
- During this area of study, we considered the fact that arterial blood moves incompressible throughout artery stenosis dimensions is $L_0/2$.
- it is preferable to work with the cylindrical coordinates (r, θ, x), where the x -axis is considered along the direction of the horizontal artery and θ and r the circumferential and radial directions, correspondingly. In the present model the flow is taken along the axial direction x and r is perpendicular to the flow. The temperature T is set to the arterial wall temperature T_w, suggesting that the wall is maintained at a constant temperature.
- In the physical model we considered blood flow along $x-axis$ and $r-axis$ is taken perpendicular to the blood flow and which is presented in Figure 2.
- A representation depicts blood moving through a cosine-shaped blood artery constricting an area $2R_0$, $R(x)$ is radius of the artery and χ is the maximum height of stenosis.

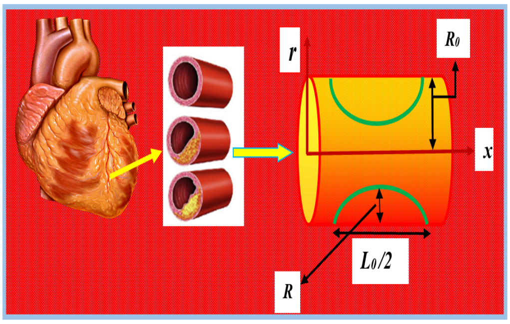

Figure 2. The artery's physical structure.

It has been decided that a profile be created should cover the stenosed area.

$$\frac{R(x)}{R_0}=\begin{cases}1-\dfrac{\chi}{2}\left(1+\text{Cos}\left(\dfrac{4\pi x}{L_0}\right)\right), & -\dfrac{L_0}{4}<x<\dfrac{L_0}{4}=R_0\\ 1 & ,otherwise\end{cases}. \tag{1}$$

The mathematical flow equations are as follows [15][16][17][18]:

$$\frac{\partial(ru)}{\partial x}+\frac{\partial(rv)}{\partial r}=0, \tag{2}$$

$$u\left(\frac{\partial}{\partial x}+v\frac{\partial}{\partial r}\right)u=\frac{\mu_{nf}}{\rho_{nf}}\left(1+\frac{1}{\beta}\right)\frac{\partial}{r\partial r}\left(r\frac{\partial u}{\partial r}\right)-\frac{\sigma_{nf}B^2}{\rho_{nf}}u, \tag{3}$$

$$\left(u\frac{\partial}{\partial x}+v\frac{\partial}{\partial r}\right)T=\frac{k_{nf}}{(\rho C_p)_{nf}}\frac{\partial}{r\partial r}\left(r\frac{\partial T}{\partial r}\right)+\frac{\sigma_{nf}B^2u^2}{(\rho C_p)_{nf}}. \tag{4}$$

The boundary conditions are [16][17]

$$\left.\begin{aligned}&u=u_0,\, v=0 \text{ and } T=T_w \quad at\ \ r=R(x),\\ &u\to 0, \text{ and } T\to T_\infty \qquad as\ r\to\infty.\end{aligned}\right\}. \tag{5}$$

The thermo physical nature are

$$\Phi_1=\frac{\mu_{nf}}{\mu_f},\Phi_2=\frac{\rho_{nf}}{\rho_f},\Phi_3=\frac{\sigma_{nf}}{\sigma_f},\Phi_4=\frac{(\rho c_p)_{nf}}{(\rho c_p)_f},\Phi_5=\frac{k_{nf}}{k_f}. \tag{6}$$

The continuity eq. (1) can be satisfied by introducing stream function ψ for u and v such that.

$$u=\frac{1}{r}\frac{\partial\psi}{\partial r},\ v=-\frac{1}{r}\frac{\partial\psi}{\partial x}. \tag{7}$$

Then Eqs. $(3-4)$ converted as

$$\frac{1}{r}\frac{\partial\psi}{\partial r}\frac{\partial}{\partial x}\left(\frac{1}{r}\frac{\partial\psi}{\partial r}\right)-\frac{1}{r}\frac{\partial\psi}{\partial x}\frac{\partial}{\partial r}\left(\frac{1}{r}\frac{\partial\psi}{\partial x}\right)=\frac{\mu_{nf}}{\rho_{nf}}\left(1+\frac{1}{\beta}\right)\frac{\partial}{r\partial r}\left(\frac{\partial^2\psi}{\partial r^2}-\frac{1}{r}\frac{\partial\psi}{\partial r}\right)-\frac{\sigma_{nf}B^2}{\rho_{nf}}\frac{1}{r}\frac{\partial\psi}{\partial r}, \tag{8}$$

$$\left(\frac{1}{r}\frac{\partial\psi}{\partial r}\right)\frac{\partial T}{\partial x}-\left(\frac{1}{r}\frac{\partial\psi}{\partial x}\right)\frac{\partial T}{\partial r}=\frac{k_{nf}}{(\rho C_p)_{nf}}\frac{\partial}{r\partial r}\left(r\frac{\partial T}{\partial r}\right)+\frac{\sigma_{nf}B^2\psi_r{}^2}{(\rho C_p)_{nf}}. \tag{9}$$

The suitable self-similarity transformations are:

$$\left.\begin{aligned}&u=\frac{u_0x}{L_0}f'(\eta),\ v=-\frac{R}{r}\sqrt{\frac{u_0\upsilon_f}{L_0}}f(\eta),\ \theta(\eta)=\frac{T-T_\infty}{T_w-T_\infty}\\ &\eta=\frac{r^2-R^2}{2R}\sqrt{\frac{u_0}{\upsilon_fL_0}}.\end{aligned}\right\}. \tag{10}$$

By substituting Eq. 10 in the Eqs. (8 – 9) modified dimensionless equations are:
Modified Eq. (1) is

$$f = 1 - \frac{\chi}{2}\left(1 + \mathrm{Cos}\left(4\pi x\right)\right), \quad -\frac{1}{4} < x < \frac{1}{4} \\ = 1 \tag{11}$$

Where $f = \frac{R(x)}{R_0}$ *and* $\chi = \frac{\lambda}{R_0}$ is the dimensionless measure of stenosis in reference artery.

$$\frac{1}{\Phi_1\Phi_2}\left[\left(1+2\gamma\eta\right)\left(1+\frac{1}{\beta}\right)f''' + 2\gamma f''\right] + ff'' - f'^2 - \frac{\Phi_3}{\Phi_2}Mf' = 0 \tag{12}$$

$$\frac{\Phi_5}{\Phi_4}\frac{1}{Pr}\left[\left(1+2\gamma\eta\right)\theta'' + 2\gamma\theta'\right] + f\theta' - f'\theta + \frac{\Phi_3}{\Phi_4}MEcf'^2 = 0 \tag{13}$$

The non-dimensional boundary conditions are:

$$\left.\begin{array}{l} f(\eta) = 0,\ f'(\eta) = 1,\ \theta(\eta) = 1,\ \eta = 0 \\ f'(\eta) \to 0,\ \theta(\eta) \to 0,\ \eta \to \infty. \end{array}\right\} \tag{14}$$

Here $\gamma = \sqrt{\frac{\upsilon_f L_0}{u_0 R^2}}$ curvature parameter, $M = \frac{\sigma_f B^2 L_0}{u_0 \rho_f}$ Magnetic field parameter and $Pr = \frac{k_f}{\left(\mu C_p\right)_f}$ Prandtl number and $Ec = \frac{U_w^2}{c_p\left(T_w - T_\infty\right)}$ Eckert number.

The physical quantities of C_f and Nu are

$$C_f = \frac{2\tau_w}{\rho_f U_w^2} \tag{15}$$

Here τ_w is $\tau_w = \mu_{nf}\left.\frac{\partial u}{\partial r}\right|_{r=R}$

$$Nu = \frac{xq_w}{k_f\left(T_w - T_\infty\right)} \tag{16}$$

Where q_w is $q_w = -k_{nf}\left.\frac{\partial T}{\partial r}\right|_{r=R}$

The dimensionless form of eq. (15–16) converts

$$Re_r^{1/2} C_f = \Phi_1 f''(0), \tag{17}$$

$$Re_r^{-1/2} Nu_r = -\frac{k_{nf}}{k_f}\theta'(0). \tag{18}$$

Table 1. Thermo-physical characteristics Density, Specific heat, Heat conductivity, Electrical conductivity [19]

Property	Blood	Au	Ta
$\rho\ (kgm^{-3})$	1050	10500	16650
$C_p\ (Jkg^{-1}K^{-1})$	3617	235	686.2
$k_f\ (Wm^{-1}K^{-1})$	0.52	429	0.52
$\sigma\ (\Omega m)^{-1}$	1.33	4.5×10^7	7.7×10^6
Pr	21		

3. NUMERICAL METHODOLOGY

The ODE equations are (12–13) with BCs (14) highly nonlinear nature. These equations are implementing a mathematical procedure called the Bvp5c technique by utilizing MATLAB software. The stages of the shooting strategy are listed below:

$$f = N_1, f' = N_2, f'' = N_3, f''' = N_3', \theta = N_4, \theta' = N_5, \theta'' = N_5'$$

Employing the substitution technique to create first-order nonlinear ODEs. Construction of a comparable mathematical setup follow the below procedure.

$$N_1' = N_2$$
$$N_2' = N_3$$
$$N_3' = -\left[\frac{1}{(1+2\gamma\eta)\left(1+\frac{1}{\beta}\right)\frac{1}{\Phi_1\Phi_2}}\left[\frac{1}{\Phi_1\Phi_2}2\gamma N_3 + N_1N_3 - (N_2)^2 - \frac{\Phi_3}{\Phi_2}MN_2\right]\right]$$
$$N_4' = N_5$$
$$N_5' = -\left[\frac{1}{(1+2\gamma\eta)\frac{\Phi_5}{\Phi_4}\frac{1}{Pr}}\left[\frac{\Phi_5}{\Phi_4}\frac{1}{Pr}2\gamma N_5 + N_1N_5 - N_2N_4 + \frac{\Phi_3}{\Phi_4}MEc(N_2)^2\right]\right]$$

As well as the boundary conditions are

$$\left.\begin{array}{l} N_1(\eta) = 0,\ N_2(\eta) = 1,\ N_4(\eta) = 1,\ at\ \eta = 0 \\ N_2(\eta) \to 0,\ N_4(\eta) \to 0\ \ as\ \eta \to \infty. \end{array}\right\}$$

4. RESULTS AND DISCUSSION

The current study examines the movement of Casson nanofluid flow across a stenotic artery. The bvp5c approach was used to provide the required solution for the updated complex coupled equations. The findings of graphs that show the effect of several critical elements between this range of values, $0.2 < M < 0.8,\ 0.1 < \gamma < 0.4,\ 0.4 < \beta < 1.6, 1.5 < Pr < 4.5,\ \ 2.0 < Ec < 2.6$. Furthermore, we take into account the Prandtl number for blood, which is 21, in addition to taking into account two distinct instances of nanofluids. We analyze each of the parameter numbers. The bvp5c procedure in MATLAB problem solver was employed throughout this investigation's initial stage, which culminated by the present study, which was preceded by a number of key variables.

Fig. 3 demonstrations that the comparison between tiny fluid and mixed nanofluid for velocity graph, for different nanoparticle volume fractions $\phi1=\phi2$ = 0.1, 0.2, 0.3. over the velocity of nanofluid. In this case hybrid nanofluid dominating to the nanofluid case. Fig. 4 effect that the influence of *M* on velocity graph. The diminishing trend on the velocity graph is shown at higher magnetic field parameter values. Physically speaking, a Lorentz force is created when the M grows, slowing the liquid's movement. Since the Lorentz force prevents fluid from traveling, the speed of the flow decreases due to the extra opposition, which lowers the field of motion. Additionally, the magnetic force can be utilized to control the flow speed in a stenotic artery. Because the magnetic force reduces momentum, it may help to reduce shear stress and the chance of additional harm to the arterial wall.

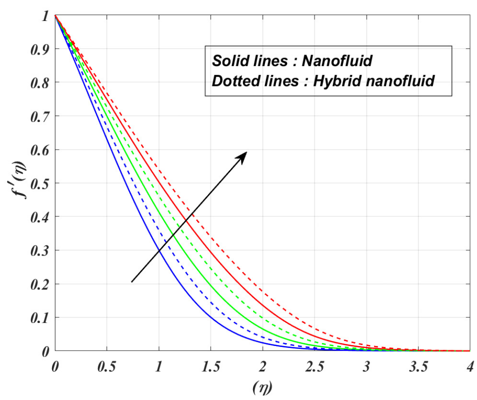

Figure 3. Comparison between nanofluid and hybrid nanofluid for velocity profile for different nanoparticle volume fraction φ = 0.1, 0.2, 0.3

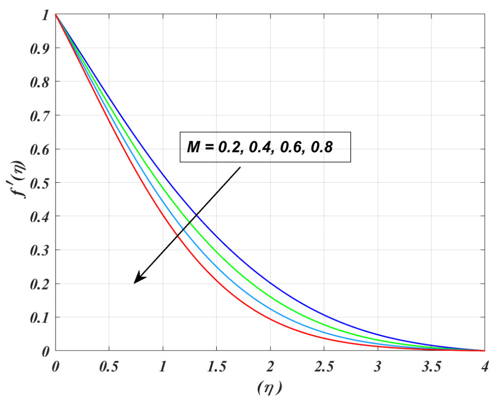

Figure 4. Influence of M on $f'(\eta)$

Fig 5. Shows that influence of γ on velocity graph. The velocity graph is enhanced as γ values are enhances. Actually, stenosis occurs in a decrease in the blood vessel membranes' dimension, therefore alters the blood flow channel's flexibility. This might lead to changes in blood flow and related trends, which could have serious health repercussions. Additionally, the pattern researchers have seen in energy graph could potentially result from this matter, which is shown in Fig 7. The impact of β on velocity graph which is shown in Fig. 6. For the larger values of the β values the velocity graph increased. physically, Raising the Casson fluid parameter, particularly implies more non-Newtonian activities, results in a slower velocity slope over stenotic sidewall veins due to increased stress induced by yield and stronger shear-thin effects. It may have significant implications for blood flow efficiency, stress transmission, and overall heart function, particularly in instances of stenotic veins when flow has become constrained.

Fig. 8 demonstrates the impact of the Pr number. A rise in Pr causes a reduction in the energy curve. physically, the amount of the Pr factor has an inverse connection with heat diffusion. Whenever the Prandtl number exceeds expectations, heat diffusion decreases, resulting in more severe thermal dispersion. Whenever the Prandtl number increases, the heat diffusion decreases. This implies that warmth spreads slower, and heat is drawn below.

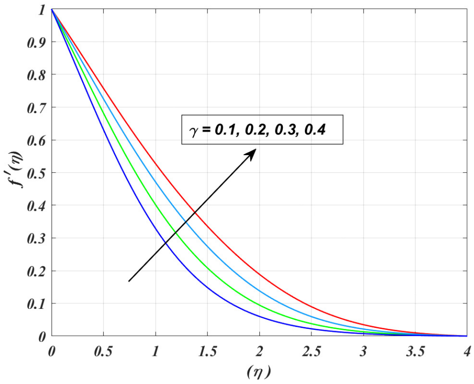

Figure 5. Influence of γ on $f'(\eta)$

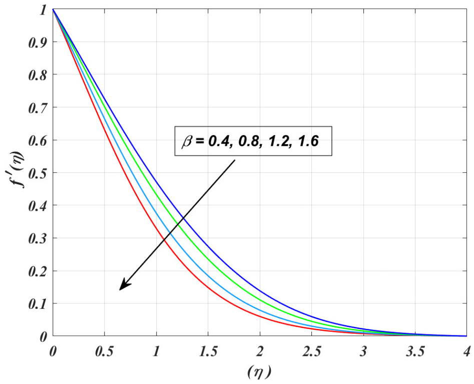

Figure 6. Influence of β on $f'(\eta)$

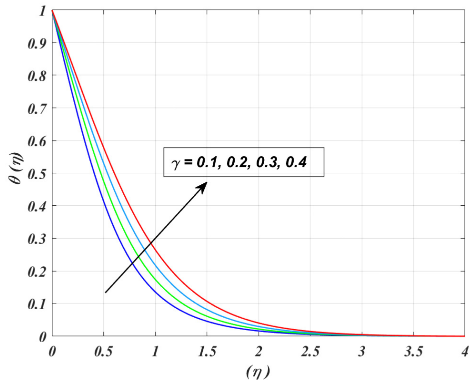

Figure 7. Influence of γ on $\theta(\eta)$

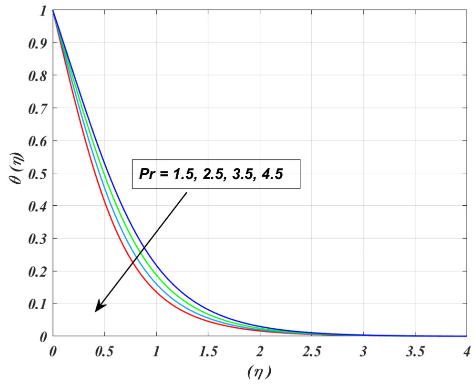

Figure 8. Influence of Pr on $\theta(\eta)$

The impact of Ec on energy graph is shown in Fig 9. Physically, the Ec impact enhances the energy and heat boundary layer thickness enhanced. Dispersion implicitly increases thermal convection, causing the thermal layer to become thicker.

Contour plots are an excellent graphical tool for learning about the complex dynamics of blood flow via constricted arteries. These factors are important for validating mathematical models, designing medical devices, diagnosing patients, and arranging medicines. If we wish to enhance the outcomes for cardiac patients, we must first understand circulatory actions, which contour charts enable when dealing with stenotic arteries. The impact of γ and M on skin friction graph is shown in Fig 10. For larger values of the M on the skin friction graph declined, a decrease in circulation of heat occurs as a result of the physical phenomena of as a result, which causes thermal dispersion to become more severe. Consequently, this results in the generation of a bigger quantity of power via activities that include motion. Despite the fact that we saw a reverse tendency on $Nu_x Re_x^{-1/2}$ graph is shown in Fig 11.

Streamlines, the exploration of liquid actions, and the representation of circulation, in specific, deliver a variety of properties that, once put into consideration combined, make them great instruments for performing research and analysis on the motions of liquids. Streamlines are particularly useful for this purpose. Especially, this holds accurate when applied to the study of the flow of fluids.

There are a variety of magnetic parameter values that have an effect on streamlines graphs, as seen in Figures 12, 13, and 14. In the direction of the primary flow, the intensity of the magnetic characteristic attracts molecules with a higher electrical conductivity. There is a correlation between the arterial network's arcs, particularly are positioned near to the location of a narrowing of and the significant increase in velocity that occurs within the blood vessels.

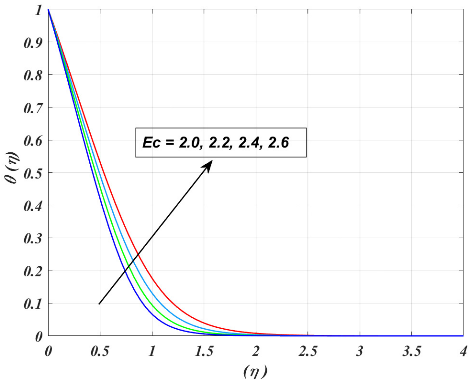

Figure 9. Influence of Ec on $\theta(\eta)$

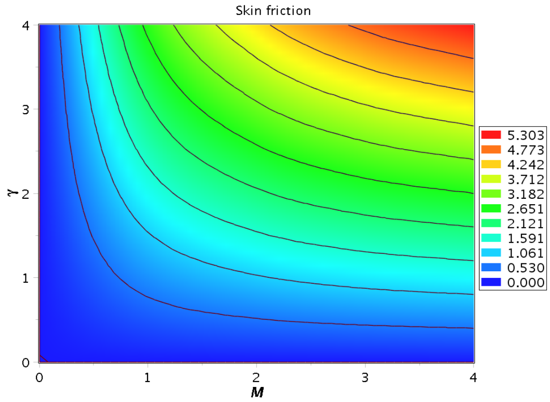

Figure 10. Influence of γ and M for $C_f Re_r^{1/2}$

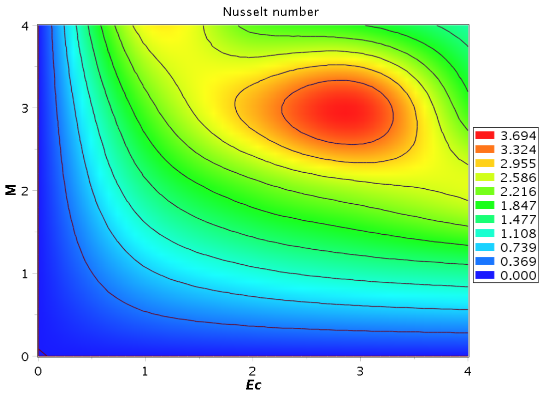

Figure 11. Influence of M and Ec for Nusselt number

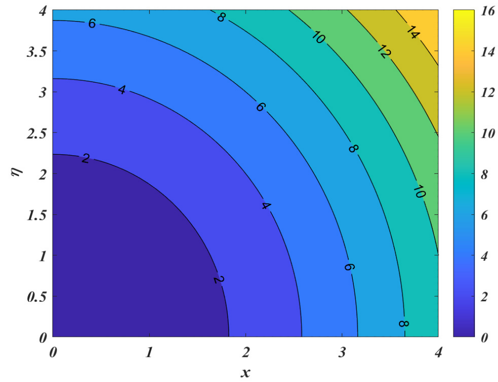

Figure 12. Streamline effects for $M = 0.5$.

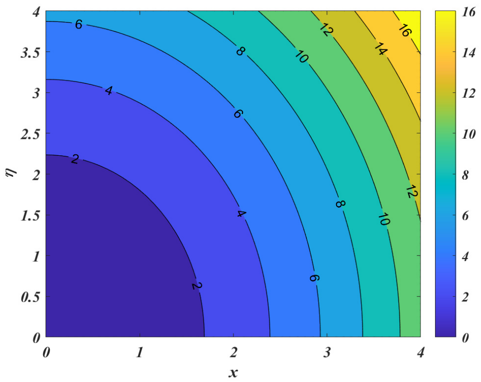

Figure 13. Streamline effects for $M = 1.0$.

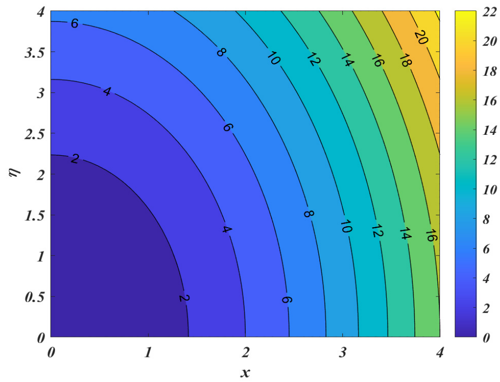

Figure 14. Streamline effects for $M = 1.5$

Table 2. Comparision results for $C_f Re_r^{1/2}$ for various values of γ *and* ϕ_1 [20].

Waqas et al.[20]		Present outcomes (bvp5c)
γ, ϕ_1	$C_f Re_r^{1/2}$	$C_f Re_r^{1/2}$
0.1, 0.01	0.939968	0.939930
0.12, 0.01	0.924794	0.924702
0.14, 0.01	0.911311	0.911346
0.1, 0.05	1.329552	1.329553
0.1, 0.1	1.175985	1.175957

5. CONCLUSIONS

The most important results are as follows:

- The circulation architecture that is already functioning has the ability to significantly enhance the transportation of medical human resources.
- Au and Ta nanoparticles are extremely well-organized for medical transportation.

- Rising the M values, results in decreasing behavior of the velocity graph.
- Enhancing the γ values, results in enhancing behavior of the velocity graph.
- The impact of γ parameter inputs as result in enhanced energy graph.
- decreasing graph in fluid temperature is instigated by a rise in *Pr* values.
- In the present model, the *Cf* and *Nu* there is no tendency at an increasing values of the *M*.

A few recommendations for possible future study that may be included in the scope of the present investigation are provided in the following paragraphs.

- The effect of magnetic field can be estimated with the various non-Newtonian fluids like Maxwell model, Casson fluid and Sisko fluid.
- The mathematical findings obtained from the feature study may be confirmed via the execution of experimental studies.
- Finding a computational method to a multi-phase issue may be proficient through the procedure of execution an investigation.
- It is possible to deal with the theoretical framework by using a method that is known as neural network technology.
- When it comes to enhancing heat transfer as well as biochemical linkages, it is feasible to identify the components which have the greatest ability for performing so.
- Personalized therapy that takes into account the unique characteristics of every single client will undoubtedly have a prominent position in the next developments. The research that is now being conducted is significant in a number of fields that fall under the general heading of healthcare.

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Disclosure statement
No potential conflict of interest was reported by the author(s).

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ПОТОК КЕССОНОВОЇ КРОВІ, ЩО МІСТИТЬ НАНОЧАСТИНКИ AU I TA, ПО СТЕНОТИЧНІЙ АРТЕРІЇ

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Обчислювальна динаміка рідини зосереджує увагу на дослідженнях кровотоку через звужені артерії через актуальність цих питань для біологічних досліджень. Основна мета цього дослідження – з'ясувати, як наночастинки впливають на кровотік через звужену артерію. У рамках нашого дослідження теоретичного сценарію потоку ми досліджуємо значення руху нанорідини Кассона через серцеву артерію. Використовуючи відповідні змінні подібності delf, PDE перетворюються на ODE. Після цього безрозмірні рівняння обробляються за допомогою комп'ютерної програми MATLAB за допомогою Bvp5c. Магнітні властивості клітин кровотоку досліджували шляхом збільшення параметра магнітного поля, що призвело до зменшення кровотоку, як було передбачено. Тренд руху зменшувався, коли параметр Кассона рідини зростав. Для підвищення ефективності передачі тепла слід збільшити концентрацію частинок золота в звуженій артерії. Можна стверджувати, що наночастинки заліза корисні для доставки ліків. Наявні на даний момент методи можуть бути корисними для розподілу ліків по системі кровообігу. Теоретичні наслідки цього методу доставки ліків представлені у спосіб, які стають зрозумілішими завдяки використанню ілюстрації.

Ключові слова: *наночастинки Au і Ta; метод Bvp5c; стеноз артерії; МГД; рідина Кассона*