JOURNAL OF ALGEBRAIC STATISTICS
Volume 13, No. 2, 2022, p. 2898 - 2909
https://publishoa.com
ISSN: 1309-3452

The impact of the strength of the attractive field on the progression of non-Newtonian blood through a few stenosed and slanted arteries

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ABSTRACT

There has been some work put into the production of a numerical model to research the impact that an attractive field has on the progression of blood through a slanted different atherosclerotic corridors. It has been concluded that the Casson condition will be utilized to mirror the non-Newtonian nature of blood. Logically and graphically, the impacts of the reaction of attractive field, yield stresses, shape boundary, and tendency of supply route on speed, volumetric stream rate in stenotic segment, and divider shear pressure at the outer layer of stenosis are shown.

Keywords: Core velocity, volumetric flow rate, wall shear stress, axial distance, magnetic field intensity, Casson Fluid

1. Prologue-

MHD has a wide range of applications in clinical sciences, sciences, biomedical planning, and other fields due to coordinated efforts with the movement of fluid ways of behaving power inside seeing an alluring field. Pores, which are present in vulnerable mediums, have an effect on the flow of fluids. Research on rhythmic movement must place a strong emphasis on the evaluation of permeability in bio fluids, tissues, and organs. When the heart contracts to force blood through its proper pathways, pressure is generated. This pressure contributes to the delivery of oxygen and other nutrients to tissues and organs throughout the body. It is possible for tissue decay, bone rot, trouble, and infraction of body organs to occur when a hallway is obstructed due to stenosis, atherosclerosis, obstruction, or any number of other factors. Misra and Kar (1989) came up with the idea of using force as a fundamental strategy to concentrate on the circulation system lead by a stenosed vessel. Sharma et al. (2012) investigated the effects that MHD had on the path taken by stenotic stock through porous medium. According to the results of their survey, Darcy's number and the Hartman number both have an effect on the circulation system. Singh and Singh (2013) developed a mathematical model in order to focus on the attractive field influence on blood flow through an atherosclerotic vein that was vitally non-symmetric anyway radially symmetric. Zaman et al. (2017) took into account a pulsatile stream of blood that flows through a constricted pathway and has a penetrable quality. In their study, Lukendra et al. (2017) focused on the pulsatile circulatory system as it passed through a vulnerable porous course with delicate stenosis that was skewed and fixed. The results showed that an increase in the slip speed leads to an increase in the centre point circulatory system speed and volumetric stream rate, while the opposite was seen when the appealing field was extended. Ponalaguswamy and Priyadarshini (2018) suggested several investigations into the Casson fluid model. The creators mulled over pulsatile flow in porous bifurcated conductors that were influenced by alluring that was not entirely set in stone for body speed increase. The physiological conditions of the human body are heavily dependent on the organization of the circulatory system's beats per minute. Studies of the circulatory system are directed by a variety of researchers under the influences of interesting field. Singh and Rathi (2010) put forth the idea that examinations of the circulatory system should take into account the fact that blood is a Newtonian fluid. Varshney et al. (2010) provided information regarding the effects of an alluring field on blood flow through various stenosis supply courses. Usman et al. (2018) presented their findings on a circulation system involving nano suspensions moving through a permeable vessel and generating power while in the presence of an attractive field. Omamoke (2020) concentrated on the power source and warm radiation ramifications for MHD blood as it passed through a bifurcated hallway and was affected by a skewered alluring field for cancerous growth treatments. The makers have discovered that their findings are useful in reducing circulatory strain issues by controlling the rates at which the circulatory system operates. Orizaga et al. (2020) concentrated their research on the problem of drug transport in syphoned vein circulation systems that had atherosclerosis. They considered the scattering properties in relation to the treatment of patients who had atherosclerosis. The research conducted by Kumar et al. (2021) focused on the effects of force source and engineered reaction on the MHD circulatory system in permeable bifurcated veins with a skewed alluring field taking into consideration carotid body malignant growth treatments that develop in bifurcated supply courses.

2. Statement of the Problem in its Current Form:

The geometry of the stenosis, expressed in a form that does not require dimensions, is given as

$$\frac{R'}{R_0} = 1 - A[(l_0{}')^{s-1}\{\omega z' - nd' - (n-1)l_0{}'\} - \{\omega z' - nd' - (n-1)l_0{}'\}^s] \quad ; \quad n(d' + l_0{}') - l_0{}' \leq \omega z' \leq n(d' + l_0{}') \qquad (1)$$

$= 1$; otherwise

Where $A = \frac{\delta}{R_0(l_0{}')^s} \frac{s^{s/s-1}}{s-1}$ and δ be the highest point that the stenosis can reach at

$$z = \frac{nd' + (n-1)l_0{}' + l_0{}'/s^{1/s-1}}{\omega}$$

The Navier–Stokes equation is an equation that

$$-\frac{\partial p'}{\partial z'} + \frac{1}{r'}\frac{\partial}{\partial r'}(r'\tau') + \mu_0 M \frac{\partial H'}{\partial z'} + \frac{sin\alpha}{F'} = 0 \qquad (2)$$

Where r' and z' represent the radial and axial coordinates, respectively, the magnetic permeability μ_0, the magnetization M, the intensity H' of the magnetic field, the pressure P', and the shear stress τ'.

It can be shown that the constitutive equation for Casson fluid is

$$\left(\sqrt{\tau'} - \sqrt{\tau_0{}'}\right) = \sqrt{K\left(\frac{\partial w'}{\partial r'}\right)};\ \tau' > \tau_0{}' \qquad (3)$$

$$\frac{\partial w'}{\partial r'} = 0; \tau' \leq \tau_0{}' \qquad (4)$$

Where $\tau_0{}'$ represents the yield stress and K represents the flow consistency index of blood.

The problem's boundary conditions and their associated variables

$w' = 0$ at $r' = R'$(z) (5a)

τ' is finite at $r' = 0$ (5b)

In the core region $w' = w_c{}'$ at $r' = R_c{}'$ (5c)

Where $w_c{}'$ is the velocity of the core.

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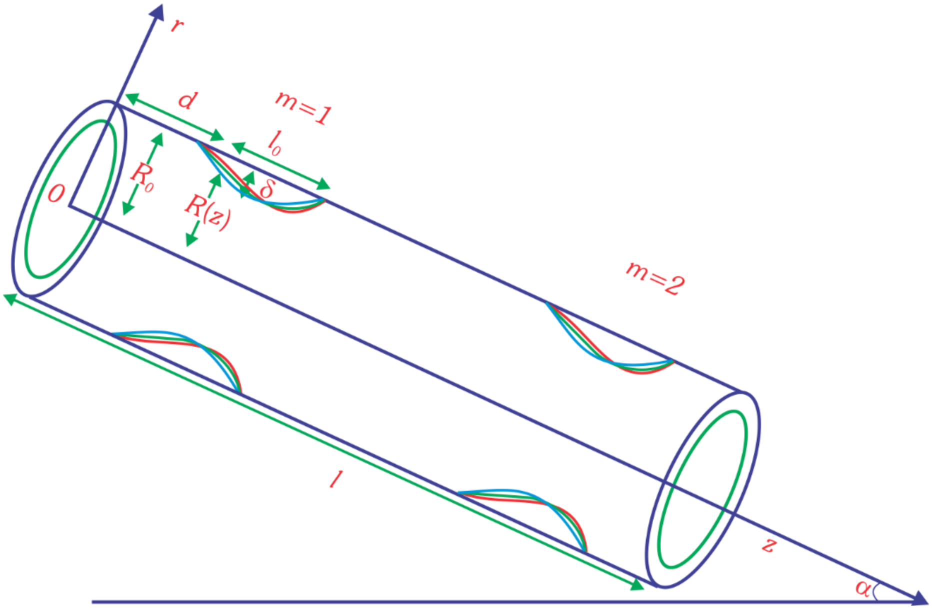

Figure 1: Geometry of Inclined Artery having multiple stenosis

3. The Approach to Solving the Problem:

The following is a non-dimensional system for your consideration.

$$r = \frac{r'}{R_0}, z = \frac{z'}{l}, R = \frac{R'}{R_0}, P = \frac{P'}{\rho\, u_0{}^2}, w = \frac{w\prime}{u_0}, \tau = \frac{\tau'}{\rho u_0{}^2}, d = \frac{d'}{l}, l_0 = \frac{l_0{}'}{l}, H = \frac{H'}{H_0} \tag{6}$$

Where H_0 exactly does the transverse external uniform continuous magnetic field exist.

The geometry of the stenosis, expressed in a form that does not require dimensions, is given as

$$\frac{R}{R_0} = 1 - A\left[l_0{}^{s-1}\{\omega z - nd - (n-1)l_0\} - \{\omega z - nd - (n-1)l_0\}^s\right] ; n(d + l_0) - l_0 \leq \omega z \leq n(d + l_0) \tag{7}$$

$= 1;$ or else

Where $A = \frac{\delta}{R_0 l_0{}^S} \frac{s^{s/s-1}}{s-1}$ and δ be the highest point that the stenosis reaches at

$$z = \frac{nd+(n-1)l_0+l_0/s^{1/s-1}}{\omega}$$

The solution to equations (2) through (4) is

$$-\frac{\partial p}{\partial z} + \frac{1}{r}\frac{\partial}{\partial r}(r\tau) + g_1\frac{\partial H}{\partial z} + \frac{\sin\alpha}{F} = 0 \tag{8}$$

$$\left(\sqrt{\tau} - \sqrt{\tau_0}\right) = g_2\sqrt{\left(\frac{\partial w}{\partial r}\right)}; \tau > \tau_0 \tag{9}$$

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$$\frac{\partial w}{\partial r} = 0; \tau \leq \tau_0 \tag{10}$$

Where $g_1 = \frac{\mu_0 M H_0}{\rho {u_0}^2}$ and $g_2 = \sqrt{\frac{K}{\rho u_0 R_0}}$

After this, the boundary conditions (5a-5c) will be considered to be

$w = 0$ at $r = R(z)$ (11a)

τ is finite at $r = 0$ (11b)

Within the central part of the $w = w_c$ at $r = R_c$ (11c)

Regarding the application of the analytical technique in Equations 8–10 and the utilization of boundary conditions (11a, 11b, 11c)

The following is an expression for the velocity$w$, as well as the core velocity w_c:

$$w = \frac{1}{{g_2}^2}\left[\frac{1}{4}(P - g_1 h - f)(r^2 - R^2) + \tau_0(r - R) - \frac{2}{3}\sqrt{2\tau_0}\sqrt{(P - g_1 h - f)}\left(\mathrm{r}^{3/2} - \mathrm{R}^{3/2}\right)\right] \tag{12}$$

$w = w_c$ at $r = R_c$

$$w_c = \frac{1}{{g_2}^2}\left[\frac{1}{4}(P - g_1 h - f)({R_c}^2 - R^2) + \tau_0(R_c - R) - \frac{2}{3}\sqrt{2\tau_0}\sqrt{(P - g_1 h - f)}\left({R_c}^{3/2} - \mathrm{R}^{3/2}\right)\right] \tag{13}$$

The formula for determining the volumetric flow rate, Q, is:

$$Q = 2\pi\left[\int_0^{R_c} r w_c\, dr + \int_{R_c}^{R} r w\, dr\right] = 2\pi(Q_c + Q_n)$$

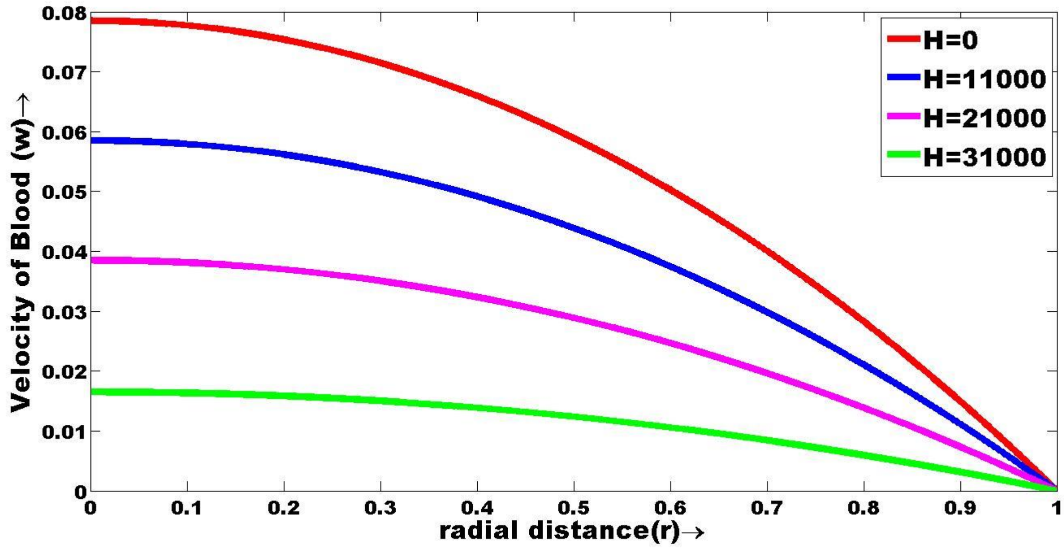
$$Q = \frac{\pi}{{g_2}^2}\left[\frac{1}{8}(P - g_1 h - f)\left(({R_c}^4 - R^4\right) + \frac{1}{3}\tau_0\left({R_c}^3 - R^3\right) - \frac{2}{7}\sqrt{2\tau_0(P - g_1 h - f)}\left({R_c}^{7/2} - \mathrm{R}^{7/2}\right)\right] \tag{14}$$

The wall shear stress can be calculated using the following formula:

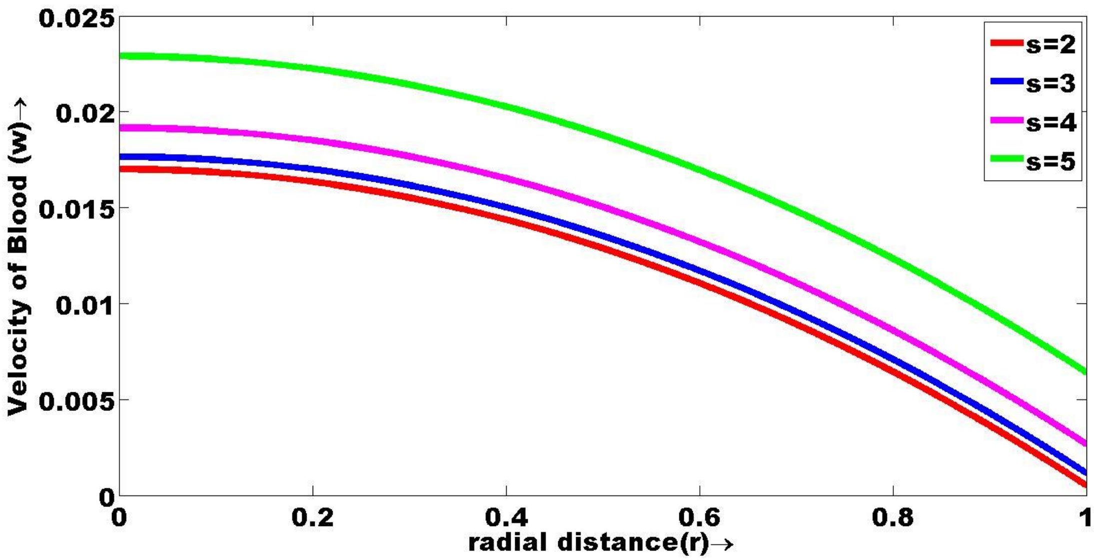
$$\tau_w = -K\left(\frac{dw}{dr}\right)_{r=R}$$

$$\tau_w = -\frac{K}{{g_2}^2}\left[\frac{1}{2}(P - g_1 h - f)R + \tau_0 - \sqrt{2\tau_0}\sqrt{(P - g_1 h - f)}\ \mathrm{R}^{1/2}\right] \tag{15}$$

4. The Discussion, along with the Numerical Results:



Graph 1: Variation in the speed of blood stream concerning outspread distance with changing forces of attractive field



Graph-2: Variation in blood flow speed with respect to radial distance throughout a range of values for the stenosis form parameter

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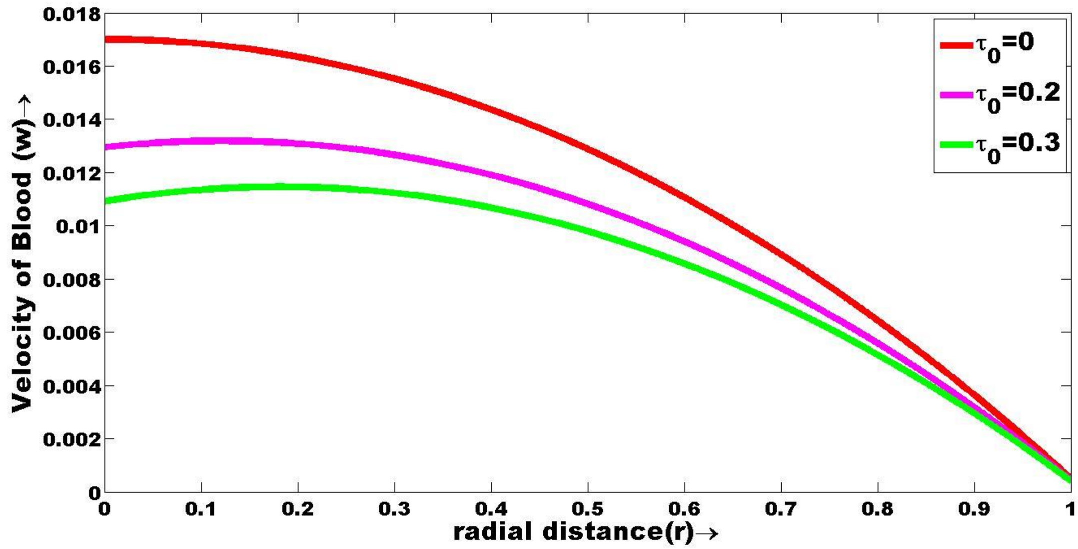
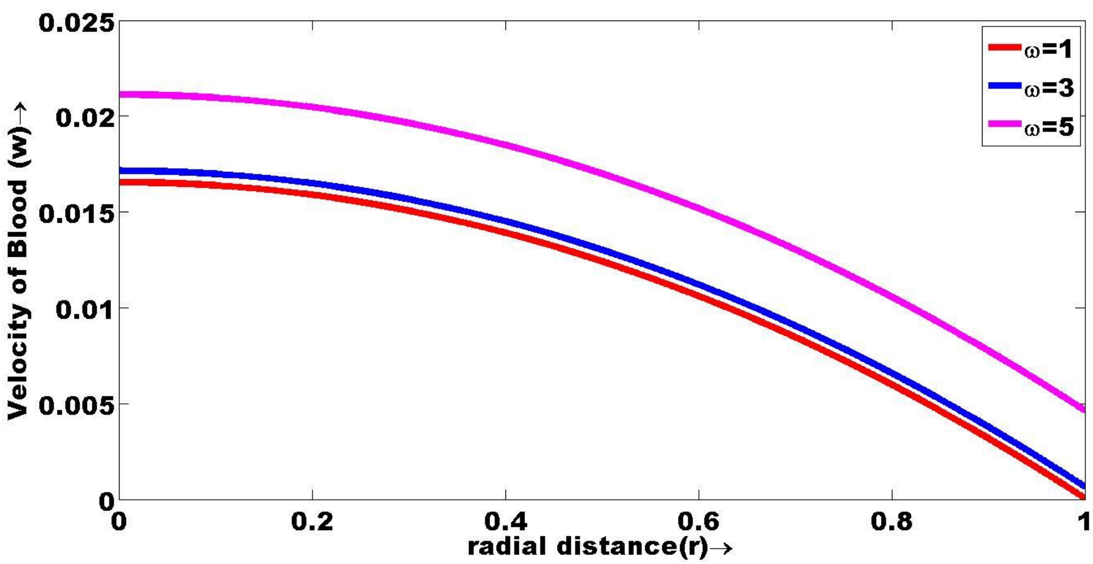


Graph-3: The variation in the speed of the blood with respect to the radial distance for various levels of yield stress



Graph-4: Variation in the speed of blood with respect to radial distance for a variety of positive numbers≥ 1

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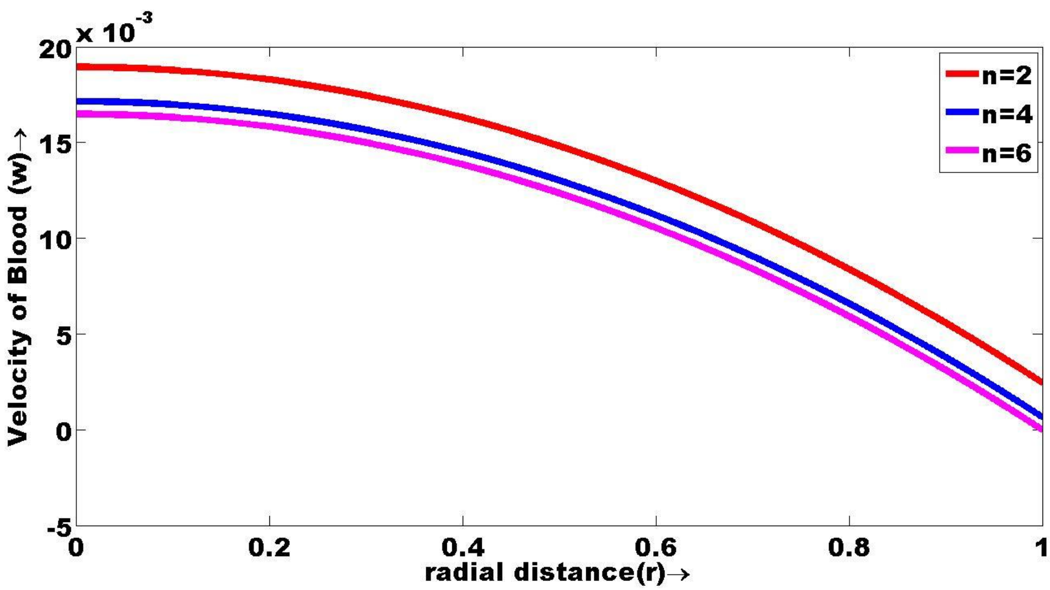
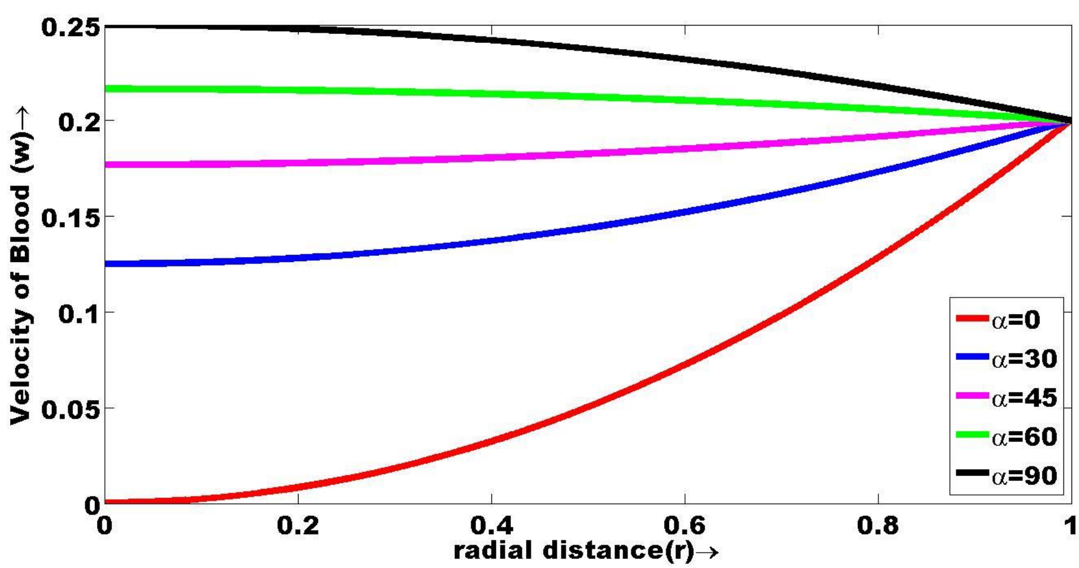


Graph-5: Variation in blood flow rate with respect to radial distance with a variety of different numbers of stenosis



Graph-6: Variation in the speed of the blood with respect to radial distance for various angles of the artery

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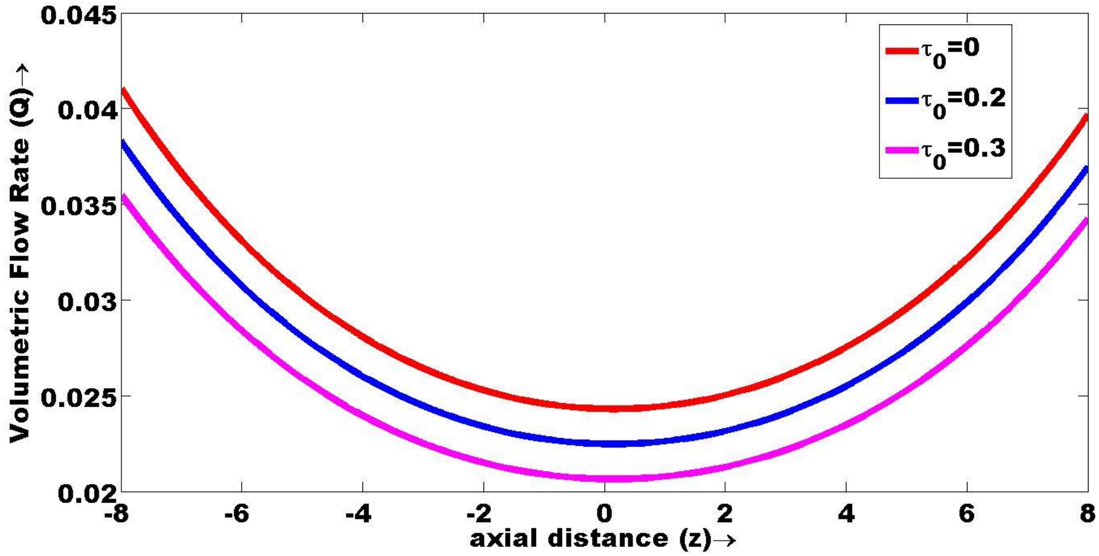
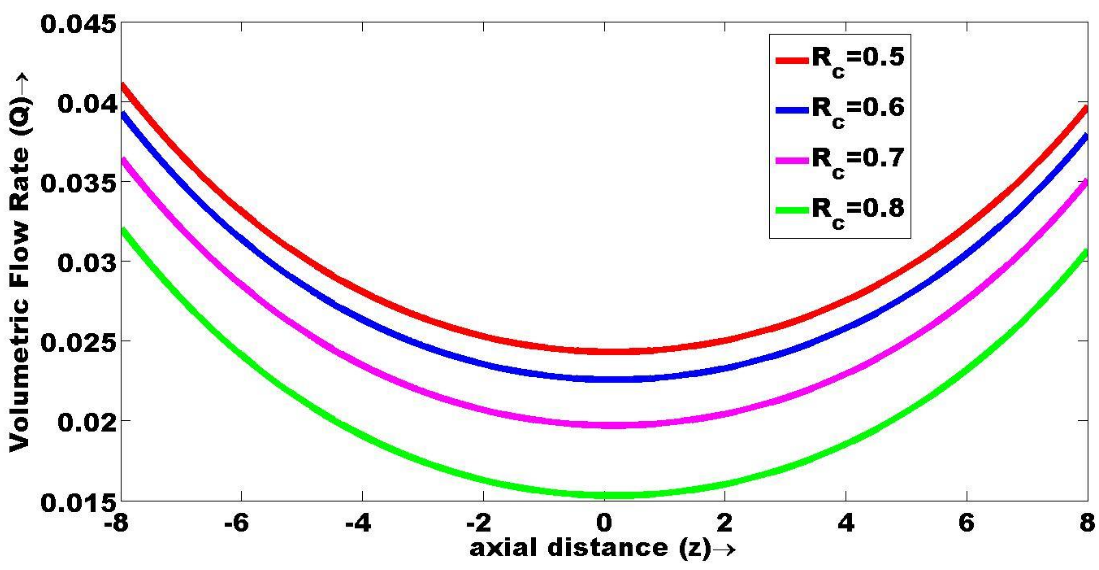
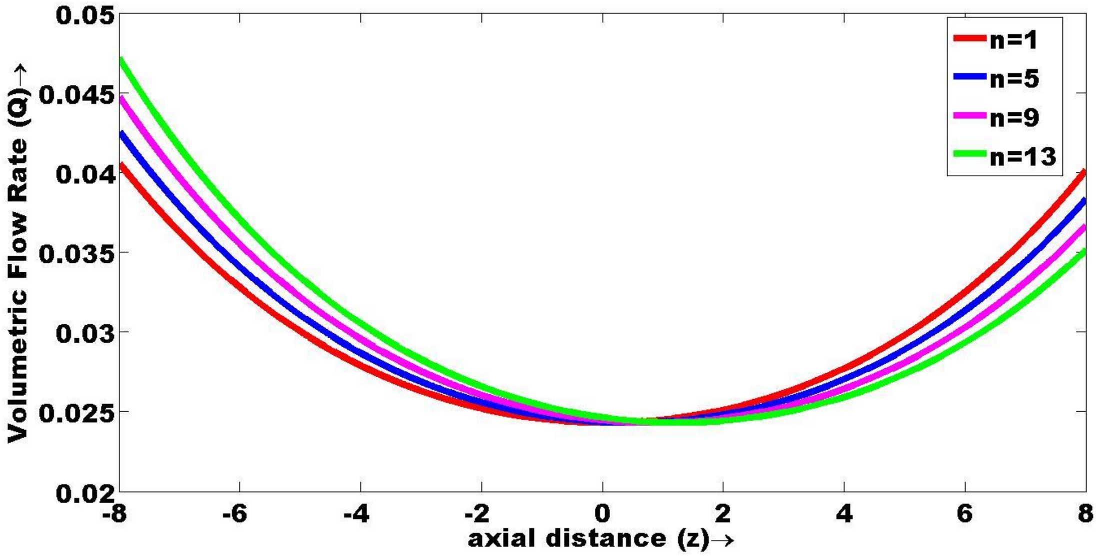


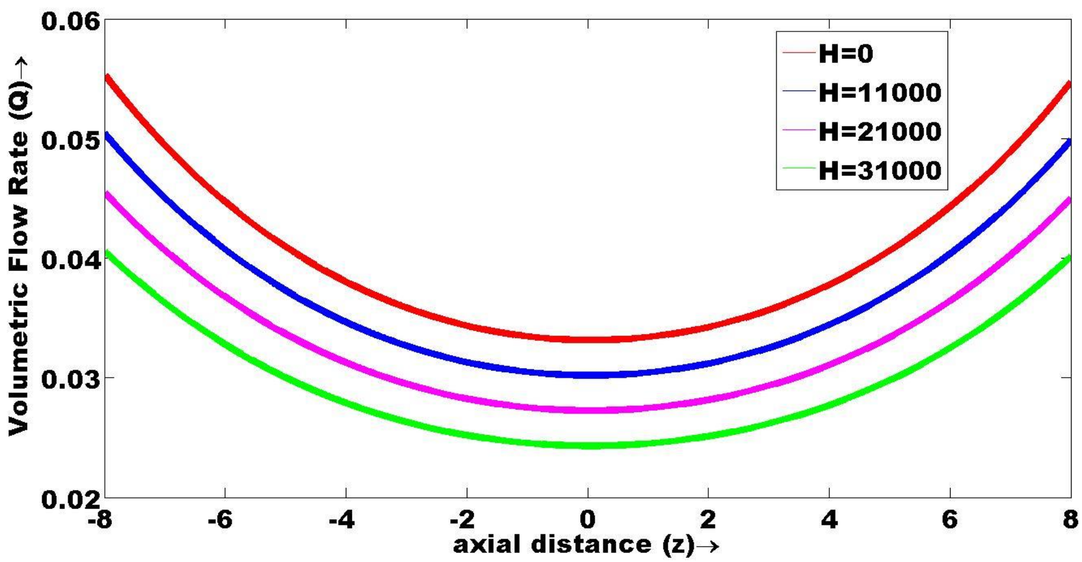
Graph-7: The relationship between the volumetric flow rate and the axial distance, given a variety of yield stress values



Graph-8: The relationship between the volumetric flow rate and the axial distance, for a variety of core radii



Graph-9: The relationship between the volumetric flow rate and axial distance, and how it varies depending on the number of stenosis.



Graph-10: The relationship between the axial distance and the volumetric flow rate, and how it varies depending on the magnetic field intensity

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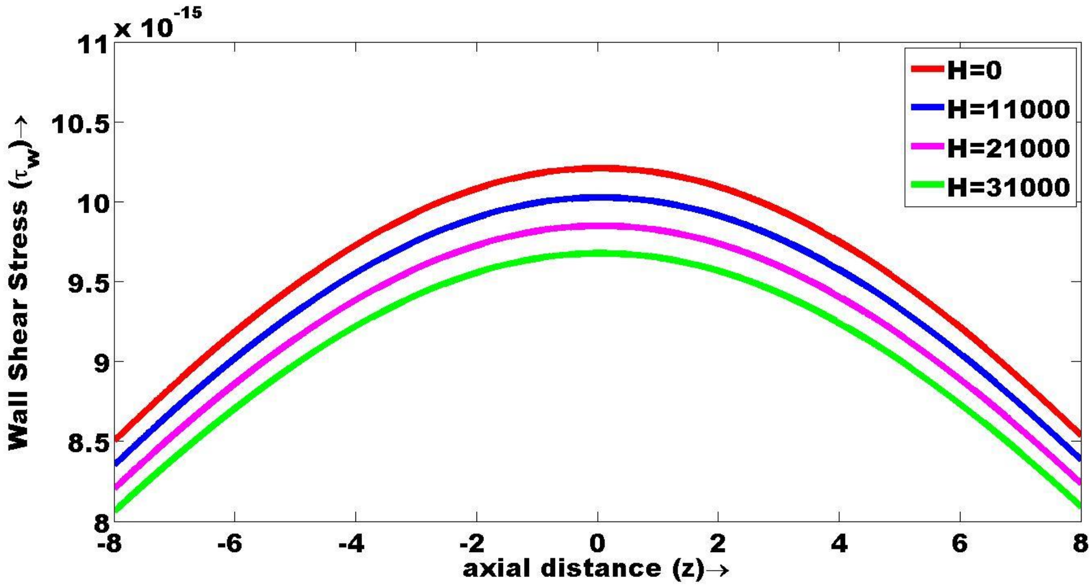
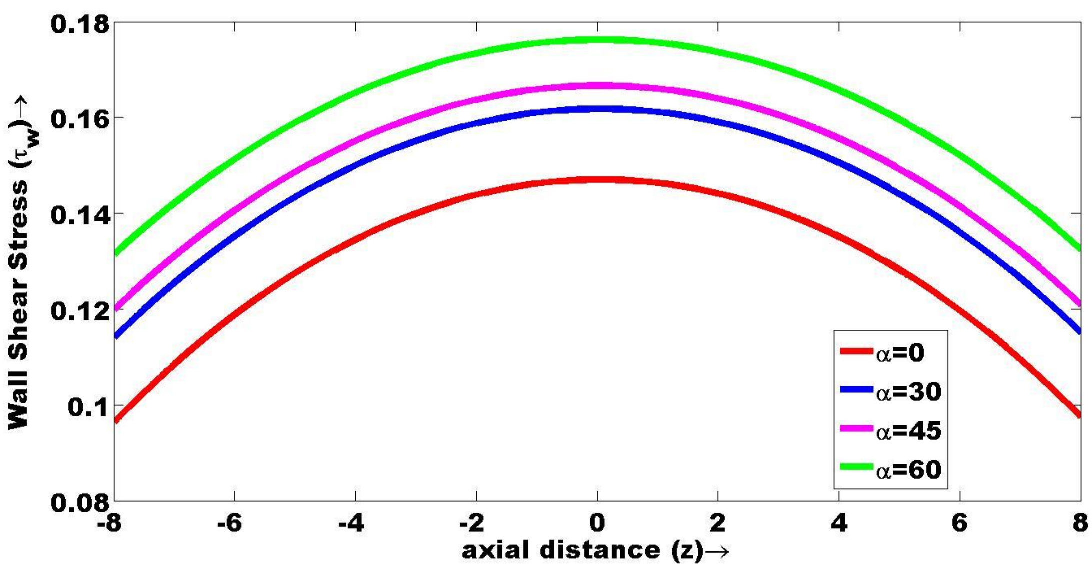


Graph-11: The relationship between the axial distance and the wall shear stress for a range of magnetic field intensities



Graph-12: Shear stress on the arterial wall as a function of axial distance and angle of the artery at various angles of inclination

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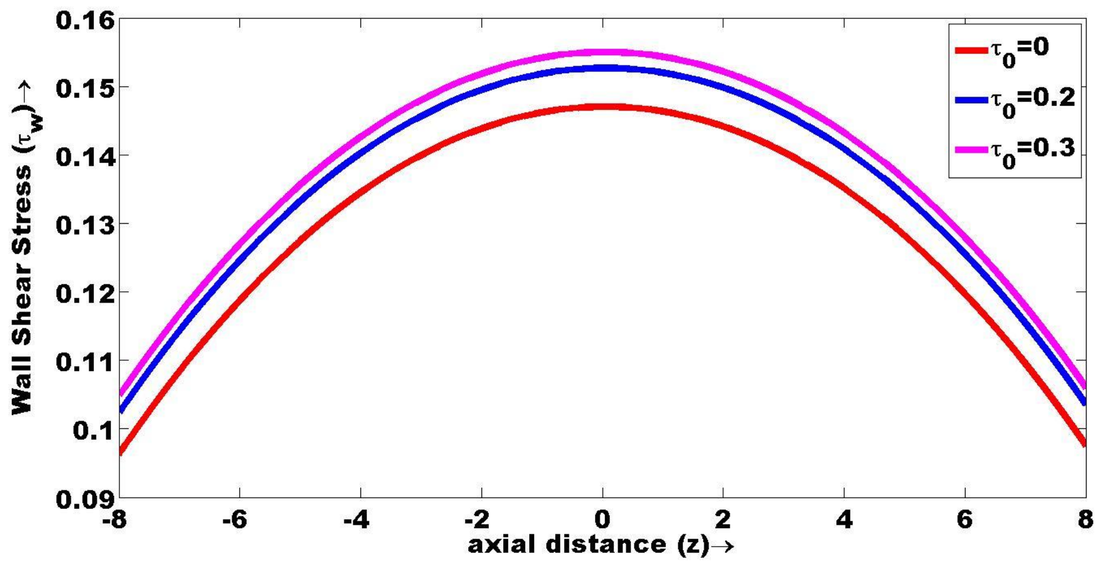

Graph-13: The relationship between the axial distance and the wall shear stress for a variety of yield stress values

The speed bend draws nearer to the beginning as the outspread distance is expanded, as found in diagrams (1), (2), (3), (4), and (5) separately. Moreover, the chart (1) shows that the speed of blood diminishes as the force of the attractive field increments. The chart (2) additionally shows the variety of speed as for the boundary that decides the math of the stenosis. The end drawn from these discoveries and portrayed in this image is that an expansion in structure boundary prompts an expansion in speed. The lessening in speed found in the diagram (3) is demonstrated to be an immediate consequence of an expansion in the yield pressure. The discoveries introduced in graphs (4) and (5) show that the speed of the blood increments if the positive steady ≥1 develops, while the speed of the blood drops at whatever point the quantity of stenosis increments. The response of the conduit's point of tendency is shown in the diagram (6). As per the aftereffect of this diagram, the speed of blood increments as the point of tendency is 0 degrees, 30 degrees, and 45 degrees, however drops when the tendency is 60 degrees or 90 degrees.

The diagrams (7), (8), (9) and (10) each show varieties of volumetric stream rate with hub distances for shifted yield pressure center span values, positive steady ≥1 values, and attractive field inclinations. As per the discoveries of the review, the pace of stream dials back relatively with rising yield pressure and expanding hub distance z. It has been seen that the stream rate decreases as the center sweep increments. It has additionally been seen that the stream rate increments when there is no attractive field present, and that it diminishes over the long haul when there is an expansion in attractive field strength.

The diagrams (11) and (12) and (13) separately show the aftereffects of the variety of divider shear pressure with pivotal distance z for different upsides of attractive field power, point of tendency of vein, and yield pressure. These charts show the aftereffects of the variety of divider shear pressure with pivotal distance z. It has been seen that the divider shear pressure ascends as the hub distance z increments from - 8 to 0 and afterward falls as z increments from 0 to 8. Notwithstanding, this pattern is switched as z moves from 8 to - 8. This is a result of a significant distinction in speed, and thus, the level of the stenosis fundamentally affects the divider shear pressure qualities. The locale in the stenosis encounters the best measure of divider shear pressure. It is additionally obvious from taking a gander at these numbers that the divider shear pressure goes down as the attractive field strength goes up, and yet it goes up when the point of tendency and the yield pressure go up.

5. Closing Comments: This study explores how the speed of blood, volumetric stream rate, and divider shear pressure are impacted by the attractive field power, yield pressure, and point of tendency of the supply route. The Casson model, which is a non-Newtonian liquid, is utilized to portray blood. More or less, we have seen that the presence of an attractive field reduces the previously mentioned stream qualities. The MHD idea can be put to use to slow the progression of blood through a human supply route framework; subsequently, the utilization of this rule can be useful in the treatment of specific cardiovascular problems.

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