International Journal of Psychosocial Rehabilitation, Vol. 25, Issue 03, 2021

ISSN: 1475-7192

Liquid Stream InDeformable Porous Materials

K U Reddy

St. Martin's Engineering College, Dhulapally (V), Kompally, Secunderabad, Telangana, India-500100
Corresponding author email id: kupendar.math@smec.ac.in

Abstract

In this paper, the stream in a deformable permeable channel limited by restricted deformable porous layer with moving rigid two equivalent plates inside seeing alluring field is investigated. The coupled directing conditions are handled the enunciations for the speed field and solid dislodging are obtained. The effects of the permeable layer thickness and the postpone the stream speed and expulsion are inspected graphically. It is seen that speed reduces with extending in the drag, while the opposite direct in the deformable.

Keywords: *Viscous flow; Porous layer; MHD; Porous layer thickness*

Introduction:

The investigation of liquid stream in an inflexible penetrable materials is an old, yet dynamic research zone grasping numerous parts of designing and science. There are, in any case, various common and mechanical procedures in which the medium through which the liquid is streaming isn't unbending. For these materials the powers which are applied by the stream can cause generous distortions of the medium. These disfigurements can, thusly, have an exceptionally enormous impact upon the liquid stream itself if the properties of the material which oversee the stream change with the misshapening. The stream and disfigurement are the coupled and an investigation

We consider the issue of fluid move through deformable fluid materials. fluidmaterials are available in countless characteristic just as building structures. Instances of normal structures incorporate natural tissue, while instances of designing structures are froths and materials. The microstructure of permeable materials is commonly mind boggling with qualities finally scale a lot littler than the size of the application: thus it is computationally not attainable to tackle the completely settled issue. Subsequently naturally visible phenomenological material models, in view of from the earlier homogenization, are normally utilized. Beginning from Biot [1], enormous number of alleged "permeable media hypotheses" of different intricacy have been created.

Naturally, the portrayal of the movement of the interstitial liquid through articuler ligament is of significance since it decides the pathways by which chondrocytes get their nourishment. In develop creatures the tidemark is known to be impermeable (Maroudas et al., [2]), accordingly leaving the synovial liquid as the main wellspring of sustenance for these phones. The pore framework is thought to be open and we limit the examination to two stages; one

ISSN: 1475-7192

strong and one liquid stage. Specifically, we represent the communication between the deformable strong and liquid, which speak to a Fluid–Structure–Interaction (FSI) issue. The homogenization of stream in deformable permeable media is likewise tended to by Iliev et al. [3] where the unique instance of the stream exhaustive a deformable channel utilizing asymptotic development.

We limit to the instance of laminar and compressible progression of the liquid. For the Fsi issue, we utilize a methodology with an acclimating interface work. The liquid period of the tissue basically water, involves up to 85 percent of the tissue by weight. The strong stage for the most part typeII collagen, proteoglycans, vague glycoprotein's, make up the staying mass of the tissue [4]. Some two-dimensional answers for this coupled arrangement of straight biphasic condition have likewise been gotten [5]. These huge two dimensional auxiliary models for the ligament bone frameworks, which are think about the activity of consistent or fluctuating width, spatially conveyed, moving burdens have requiring huge numerical calculation. Liquid vehicle specifically ligament has been explored corresponding to ligament sustenance and as a potential clarification for the watched time subordinate deformability of the material. Edward [6] found a rate decline in fluid substance of 33% after pressure of canine ligament for 30 min at an ordinary heap of 3.1*10^6 dynes/cm^2 . His resultare estimated concurrence with diminishes in fluid substance got by Linn and Sokolof [7] in similar trial.

As of late numerous creators have demonstrated the enthusiasm to contemplate the of liquid moves through permeable media due to its promising applications in designing and science. This examination is essentially propelled by the issue of the development of bio fluids in a little slender. These vessels are the littlest veins in human body. They are fixed with a layer of endothelial cells, through which the plasma and platelets stream. These layers are being displayed as deformable permeable media. This clarifies the creativity of the present work. Taking into account this application, the investigation of move through deformable permeable media is required and the arrangement accepted here is found in numerous different applications, for example, stream of dampness through permeable materials, oil recuperation and so on. Holmes and Mow [8] additionally contributed significant hypothesis for the investigation of rectilinear ligaments and organic tissue mechanics. Omens et al. [9] are examined A blend way to deal with the mechanics of skin. Yang et al.[10] have considered the conceivable job of poroelasticity in the clear viscoelastic conduct of detached heart muscle. Hughes et al. [11] are investigated A two-stage limited component model of the diastolic left ventricle. Kenyon [12] have considered A scientific model of water motion through aortic tissue. Jayaraman [13] have examined Water transport in the blood vessel divider A hypothetical report. Klanchar et al. [14] are examined Modelling water course through blood vessel tissue.

Considering the above investigations, we, in the current paper dissect the impact of deformable permeable layer on the old style Couette stream of a Jeffrey liquid between two equal plates. MHD stream of a Jeffrey liquid between a deformable permeable layer and a moving unbending plate is explored. The liquid speed, removal of the strong, mass motion and its fragmentary reduction are acquired.

NUMERICAL FORMULATION:

Consider, a consistent, completely created Colette move through a channel with strong dividers at $y = h'$ and $y = h$ and deformable permeable layer of thickness h' connected to the lower divider as appeared in Fig.1.The stream over the deformable layer is limited above by an unbending plate moving with velocity U_0.The stream region district between the plates is separated into two areas. The stream district between the lower plate $y = 0$ and the interface $y = h'$ is named as deformable porous layer though the stream locale between the interface $y = h'$ and the upper plate is $y = h$ the free stream area. The liquid speed in the free stream district and in the permeable stream area are expected separately. The dislodging because of the distortion of the strong network is taken as $(u, 0, 0)$.A weight inclination $\frac{\partial p}{\partial x} = G_0$ is applied, creating a pivotally coordinated stream in the channel.Further, a uniform transverse attractive field of solidarity B_0 is applied opposite to the dividers of channel.

Where $\bar{T}$ and $\bar{s}$ are the Cauchy's pressure tensor and additional pressure tensor individually, $\bar{p}$ is the pressure, $\bar{I}$ is the character tensor, λ_1 is the proportion of unwinding to hindrance time, λ_2 is the impediment time, $\dot{\gamma}$ is shear rate , and specks over the amounts demonstrate separation concerning time.

In view of the assumptions mentioned , the equation of motion in the deformable porous layer and free flow region are.

$$\frac{2\mu_a}{1+\lambda_1}\frac{\partial^2 v}{\partial y^2} - \phi G_0 - \mathrm{K}v - \sigma B_0^2 v = 0 \tag{1}$$

$$\mu\frac{\partial^2 u}{\partial y^2} - (1-\phi)G_0 + K\,v = 0 \tag{2}$$

$$\frac{\mu_f}{1+\lambda_1}\frac{\partial^2 q}{\partial y^2} - \sigma B_0^2 q = G_0 \tag{3}$$

DIMENSIONALIZATION QUANTITIES OF THE FLOW

The dimensional quantities.

$$\frac{y}{h} = y^*, u^* = \frac{-\mu u}{h^2 G_0}u,\ v^* = \frac{-\mu_f v}{h^2 G_0},\ q^* = \frac{-\mu_f q}{h^2 G_0}q^*, \varepsilon = \frac{h^1}{h}, M = \frac{\sigma B_0^2 h^2}{\mu_f}, \eta = \frac{\mu_f}{2\mu_a}$$

In view of the above dimensional quantities, after neglecting the stars $(*)$, the equations (1) – (3) take the following form

ISSN: 1475-7192

$$\frac{d^2v}{dy^2} - (1+\lambda_1)\delta\eta v - (1+\lambda_1)\eta M v = -\phi(1+\lambda_1)\eta \tag{4}$$

$$\frac{d^2u}{dy^2} = -(1-\phi) - \delta v \tag{5}$$

$$\frac{d^2q}{dy^2} - (1+\lambda_1)Mq = -(1+\lambda_1) \tag{6}$$

boundary conditions

$$\left.\begin{array}{l} y=0: v=0,\ u=0 \\ y=\varepsilon: q=\phi v \\ \qquad \dfrac{dq}{dy} = \dfrac{1}{\eta\phi}\dfrac{dv}{dy} \\ \qquad \dfrac{dq}{dy} = \dfrac{1}{(1-\phi)}\dfrac{du}{dy} \\ y=1: \quad q=U_0 \end{array}\right\} \tag{7}$$

THE PROBLEM AND SOLUTION

Equations (4) - (6) are with differential equations that can be solved by using the boundary conditions (7). The velocity in the deformable porous layer, solid displacement and free flow velocity are obtained,

$$v(y) = c_1 e^{ay} + c_2 e^{-ay} + \left(\frac{\phi}{\delta+M}\right) \tag{8}$$

$$u(y) = -(1-\phi)\frac{y^2}{2} - \delta\left[\frac{c_1 e^{ay}}{a^2} + \frac{c_2 e^{-ay}}{a^2} + \frac{\phi}{\delta+M}\frac{y^2}{2}\right] + c_3 y + c_4 \tag{9}$$

$$q(y) = c_5 e^{cy} + c_6 e^{-cy} + \frac{1}{M} \tag{10}$$

Where $a = \sqrt{(\delta+M)\eta(1+\lambda_1)},\ c = \sqrt{M(1+\lambda_1)}, \alpha = \phi\left[e^{c\varepsilon} + e^{c(2-\varepsilon)}\right], \beta = \frac{a}{c\phi\eta}\left[e^{c\varepsilon} - e^{c(2-\varepsilon)}\right]$

$$c_4 = \frac{\delta}{a^2}\left(\frac{-\phi}{\delta+M}\right)$$

$$c_5 = \frac{1}{\left\{e^{c\varepsilon} - e^{-a(2-\varepsilon)}\right\}}\left\{\left(U_0 - \frac{1}{M}\right)e^{c(1-\varepsilon)} + \frac{a}{c\eta\phi}\left(c_1 e^{a\varepsilon} - c_2 e^{-a\varepsilon}\right)\right\},$$

$$c_6 = \left(U_0 - \frac{1}{M}\right)e^{c} - c_5 e^{2c},$$

$$c_3 = \frac{a(1-\phi)}{\eta\phi}\left[c_1 e^{a\varepsilon} - c_2 e^{-a\varepsilon}\right] - \left\{-(1-\phi)\varepsilon - \delta\left[\frac{c_1 e^{a\varepsilon}}{a} - \frac{c_2 e^{-a\varepsilon}}{a} + \frac{\phi}{\delta+M}\varepsilon\right]\right\},$$

$$c_2 = \frac{1}{\left\{e^{a\varepsilon}\left(\alpha-\beta\right)-e^{-a\varepsilon}\left(\alpha+\beta\right)\right\}}\left\{\left[\alpha-e^{a\varepsilon}\left(\alpha-\beta\right)\right]\frac{\phi}{\delta+M}-2\left(U_0-\frac{1}{M}\right)e^{c}-\frac{\alpha}{\phi M}\right\}$$

$$c_1 = \frac{-\phi}{\delta+M}-c_2$$

RESULTS AND DISCUSSION

In this paper, consistent course through flat channel with deformable permeable materials is researched and the outcomes are examined for different physical parameters, for example, the volume part of the liquid, thickness, viscosity parameter η, upper plate velocity U_0, magnetic parameter M drag δ and Jeffrey parameter λ_1. In this study for numerical computation we used $\phi = 0.6, \delta = 1, M = 1\ \eta = 0.5, \varepsilon = 0.2, U_0 = 1$ and $\lambda_1 = 0.2$. These values are kept as common in the entire study except for varied values as displayed in Figures 2 to 17.

The variety of inflexible stream speed v in the deformable permeable layer with y is determined from condition (8) for various qualities of $\phi, \eta, \lambda_1, \varepsilon\ , U_0, M$ and δ and is shown in Figures 2, 3, 4, 5, 6, 7 and 8. From figure 2 and 3 says that the rigid velocity v increases with increasing the volume fraction ϕ and velocity thickness ε. Figure 4 outline that the speed increments with expanding viscosity parameter in the deformable porous layer. This because increasing viscosity parameter $\mu_f / 2\mu_a$, offers ascend to an expansion in the speed in the permeable layer. From figure 5, it is seen that the stream speed increments with expanding Jeffrey parameter λ_1. Figure 6 it is observed that the flow velocity decreases with increasing drag δ .From figure 7 illustrate that velocity decrease with increasing magnetic parameter. The velocity decreases due to buoyancy force. From figure 8, the impact of upper plate speed increments with expanding inflexible speed.

The variety of solid displacement u with y is determined from condition (8) for various estimations of $\varepsilon, \delta, \lambda_1, \phi, M, \eta$ and U_0 and is shown in Figures 9, 10, 11, 12, 13, 14 and 15. From figure 9 effect of the thickness parameter is increases with increasing solid displacement. Figures 10 and 11 show that the solid displacement increases with increase drag δ. It is seen that the strong relocation diminishes with the diminishing volume portion ϕ, magnetic parameter M and viscosity parameter η figures 12, 13 and 14. From figure 15 illustrate that upper plate velocity U_0 increases with increasing solid displacement.

The variation of free flow velocity q with y is calculated from equation (10) for different values of $\eta, \lambda_1, \phi, M, U_0$ and ε and is shown in Figures 16, 17 and 18. The effect of η on free flow velocity is depicted in Figure 16, which shows that free flow velocity enhances as η increases. From Figure 17 it is observed that the free flow velocity increases with increase the Jeffrey parameter λ_1. It is seen from Figure 18 that the free flow velocity decreases with decreasing volume fraction ϕ. The effect of parameter M on free flow velocity is depicted in figure 18, which shows that free flow velocity enhances as parameter M increases.

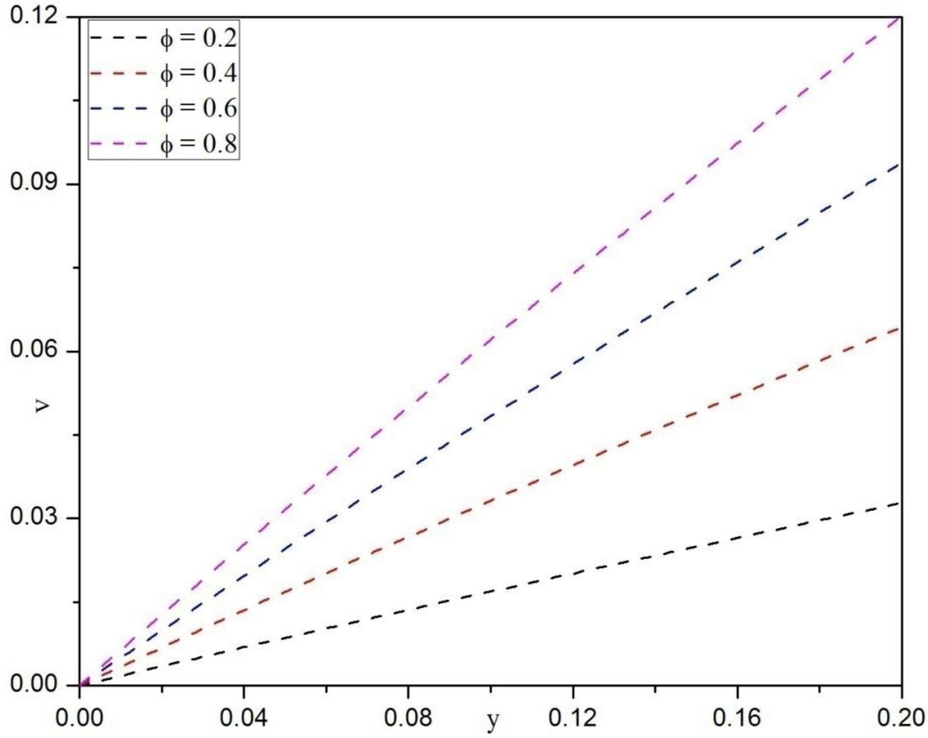

Figure 2: Inflexible speed profiles for various estimations of ϕ

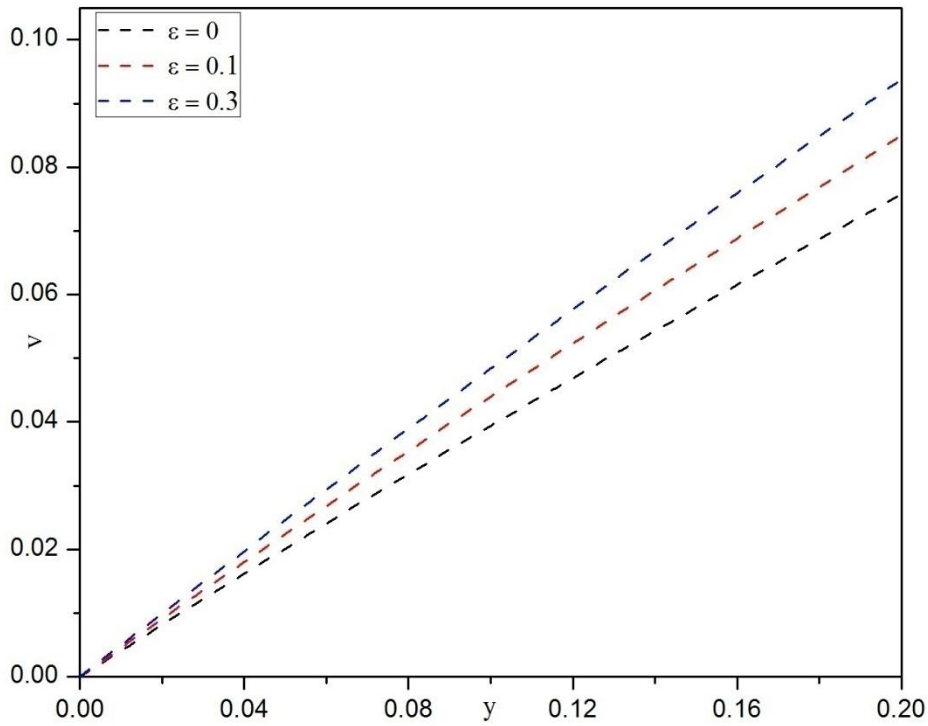

Figure 3: Inflexible speed profiles for various estimations of ε

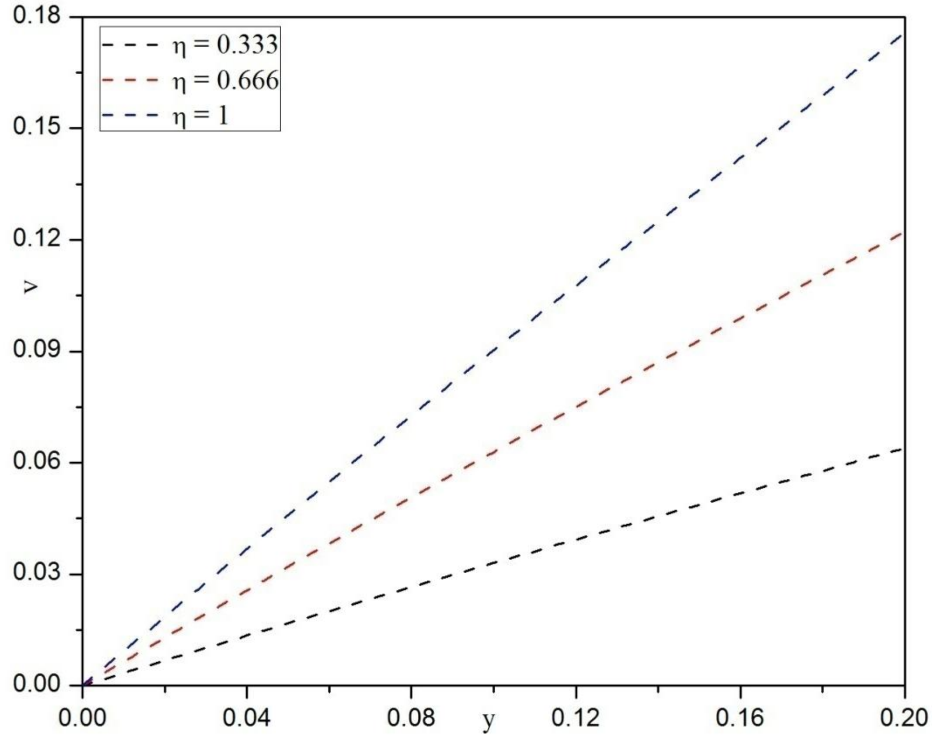

Figure 4: Inflexible speed profiles for various estimations of η

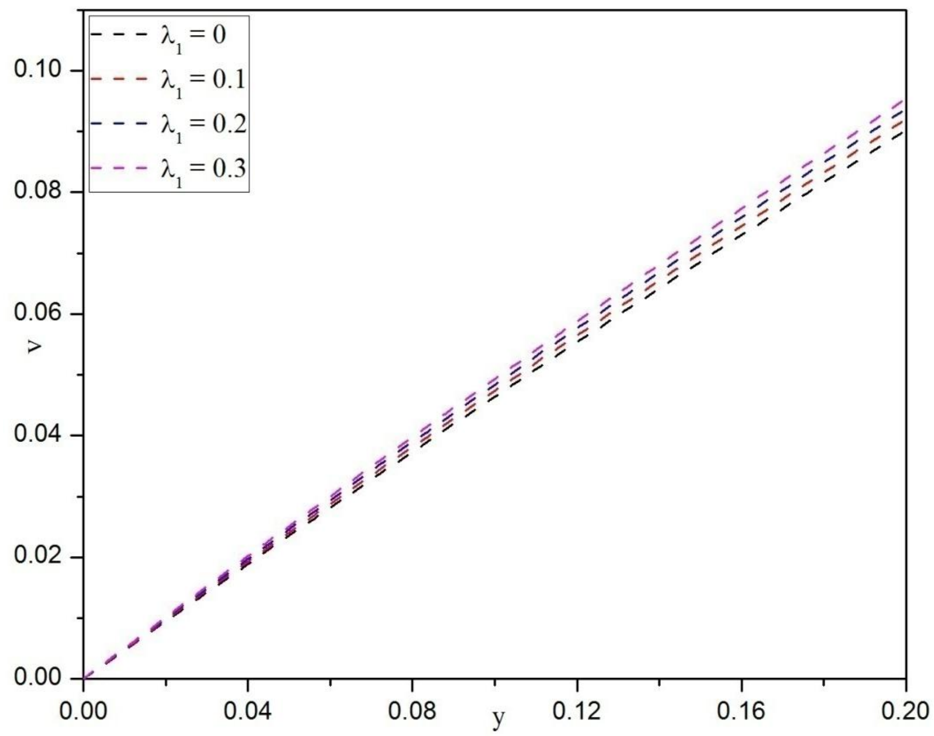

Figure 5: Inflexible speed profiles for various estimations of λ_1

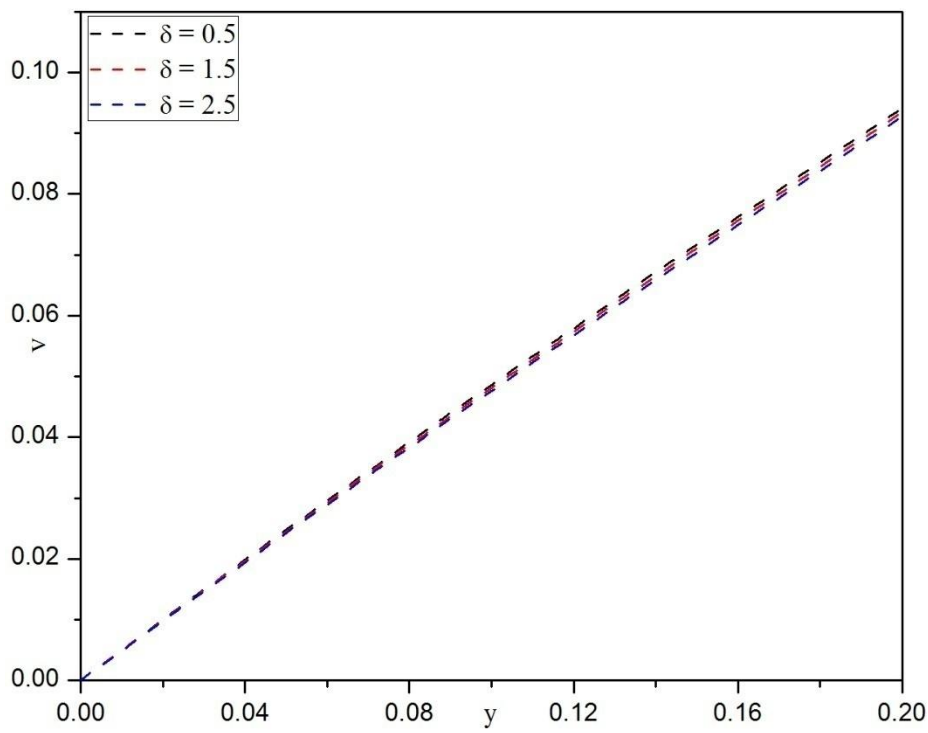

Figure 6: Inflexible speed profiles for various estimations of δ

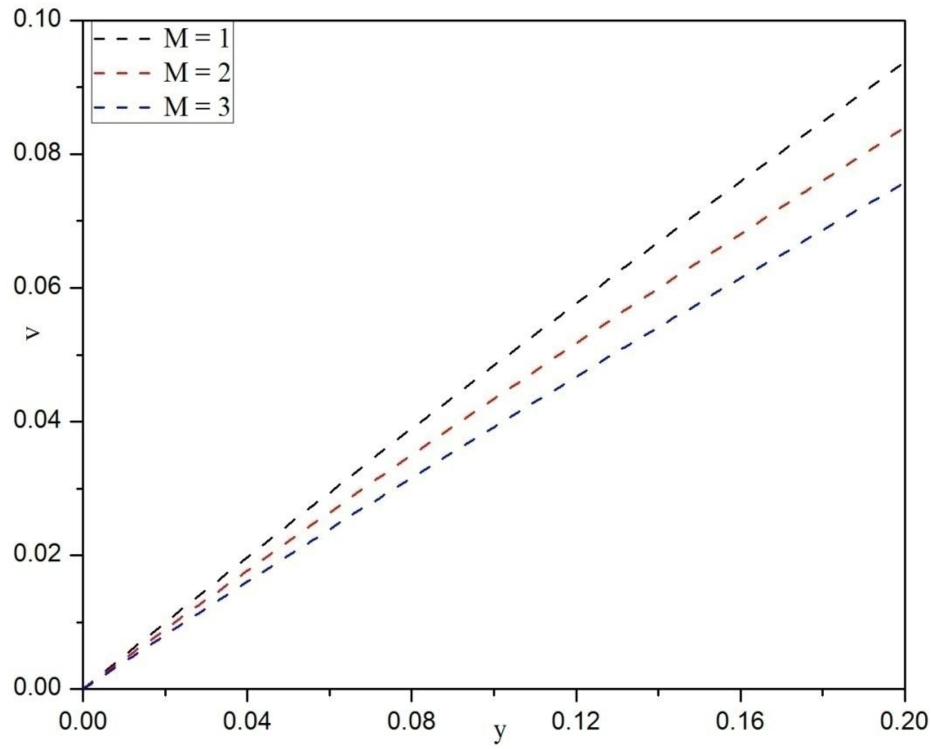

Figure 7: Inflexible speed profiles for various estimations of M

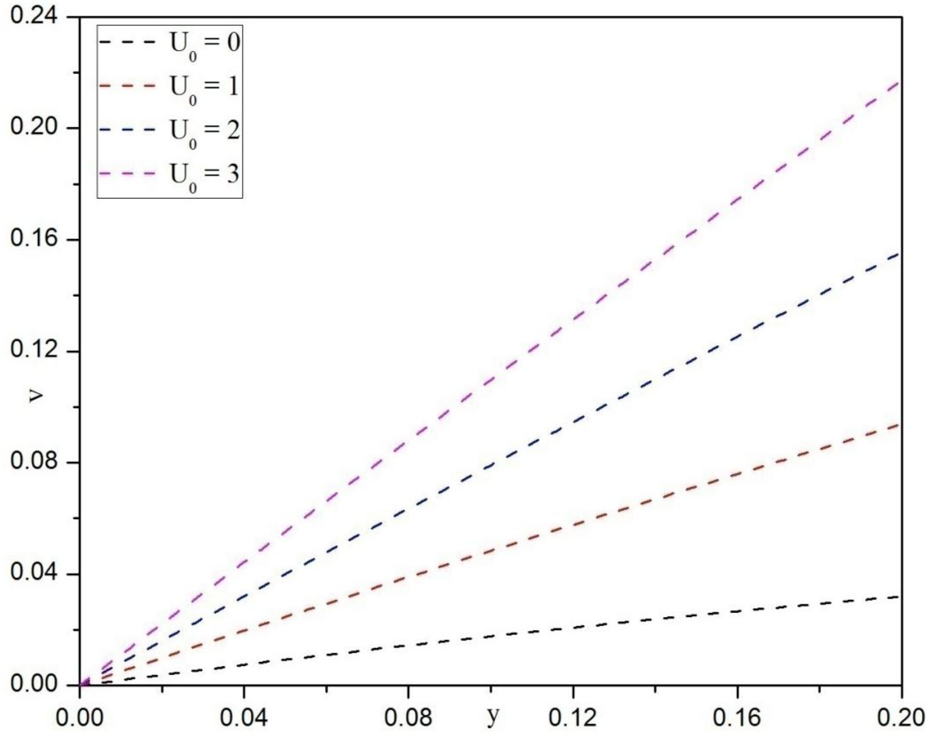

Figure 8: Inflexible speed profiles for various estimations of U_0

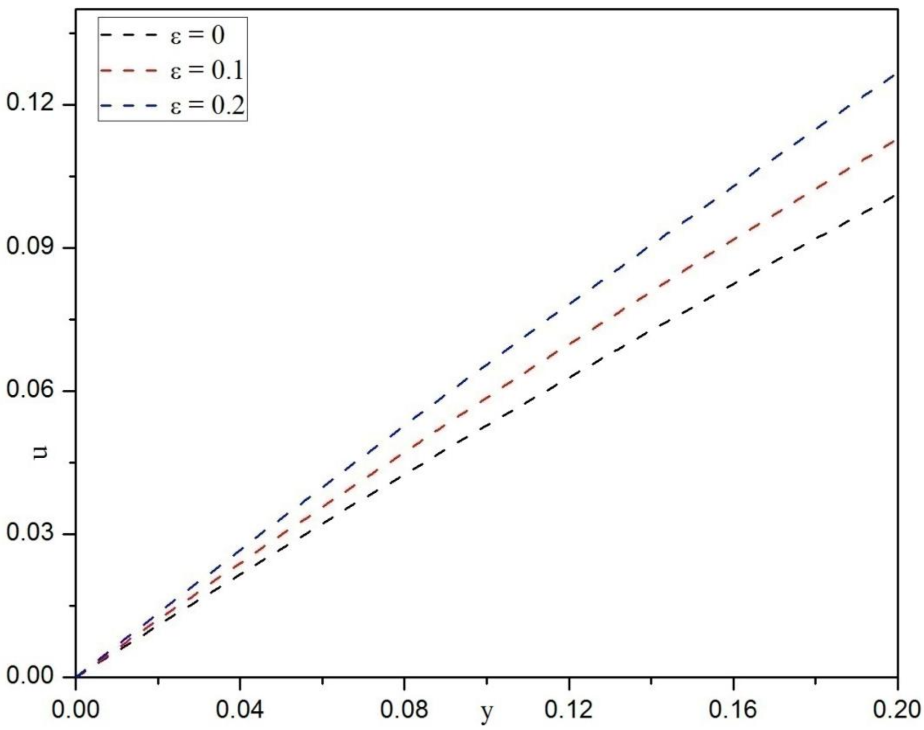

Figure 9: Deformable profiles for various estimations of ε

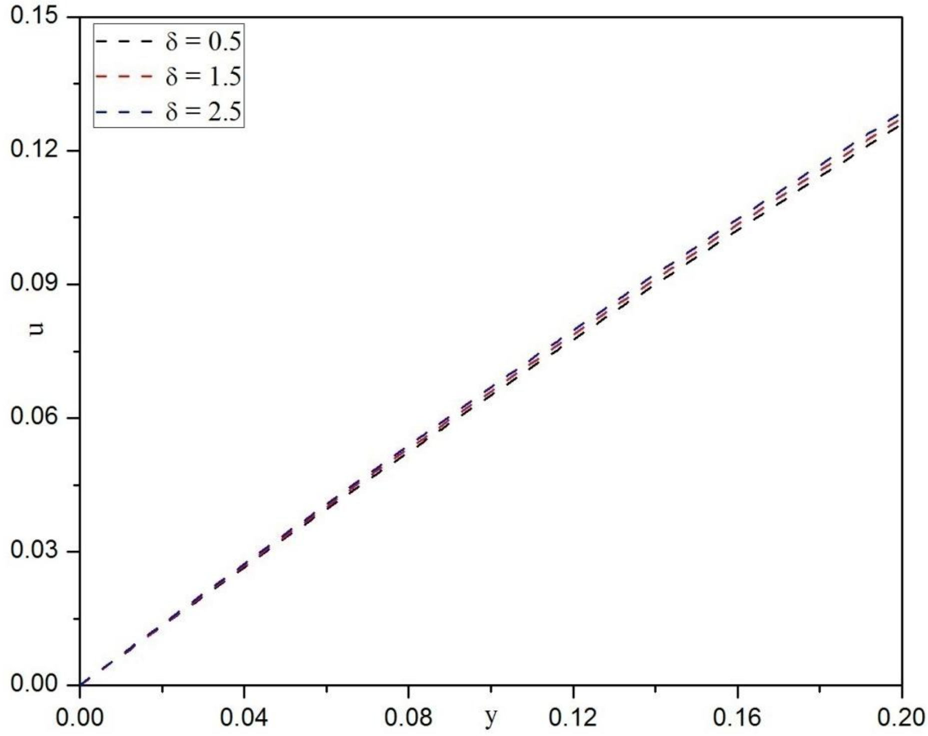

Figure 10: Deformable profiles for various estimations of δ

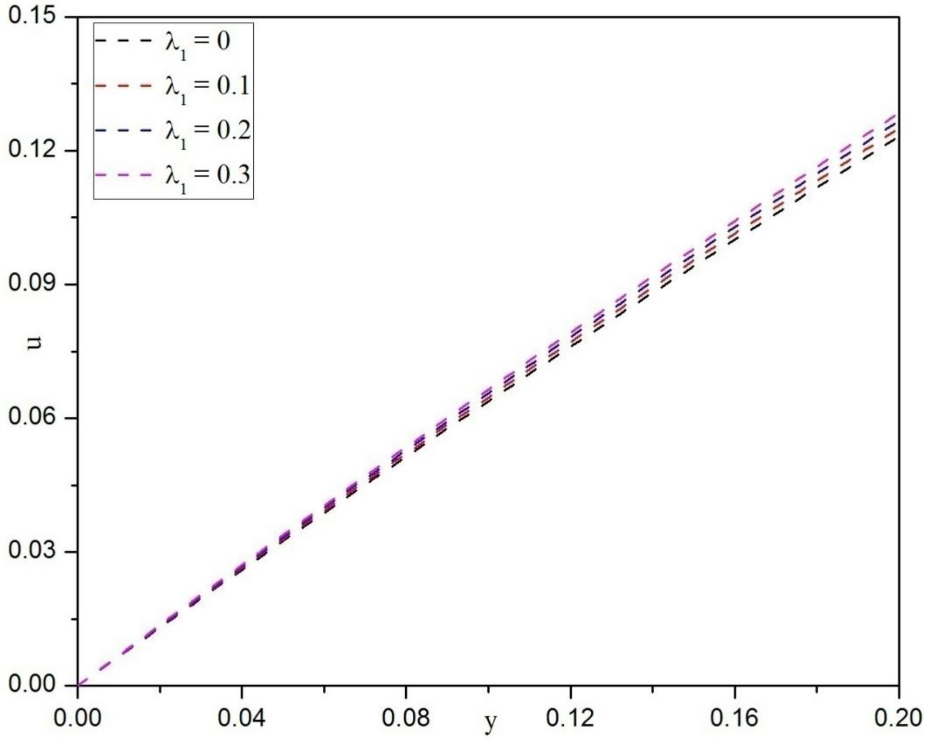

Figure 11: Deformable profiles for various estimations of λ_1

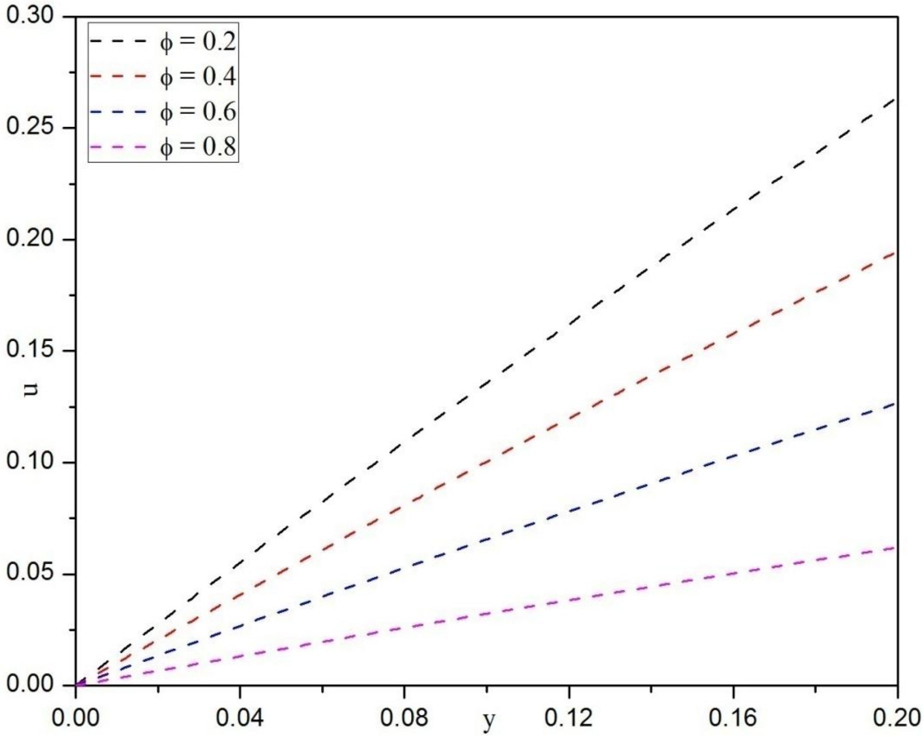

Figure 12: Deformable profiles for various estimations of ϕ

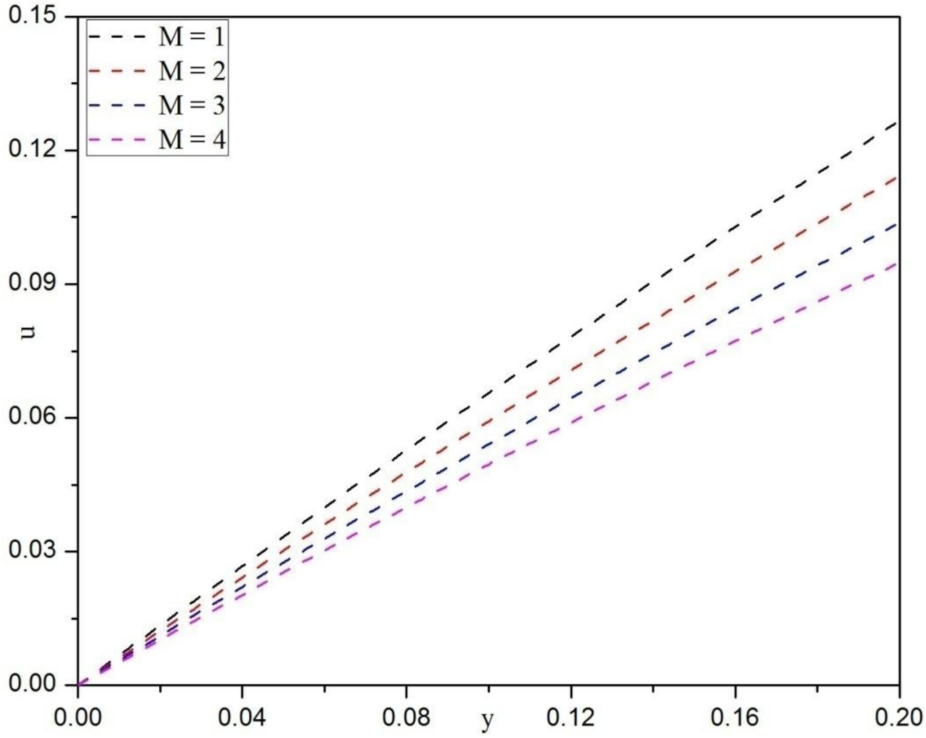

Figure 13: Deformable profiles for various estimations of M

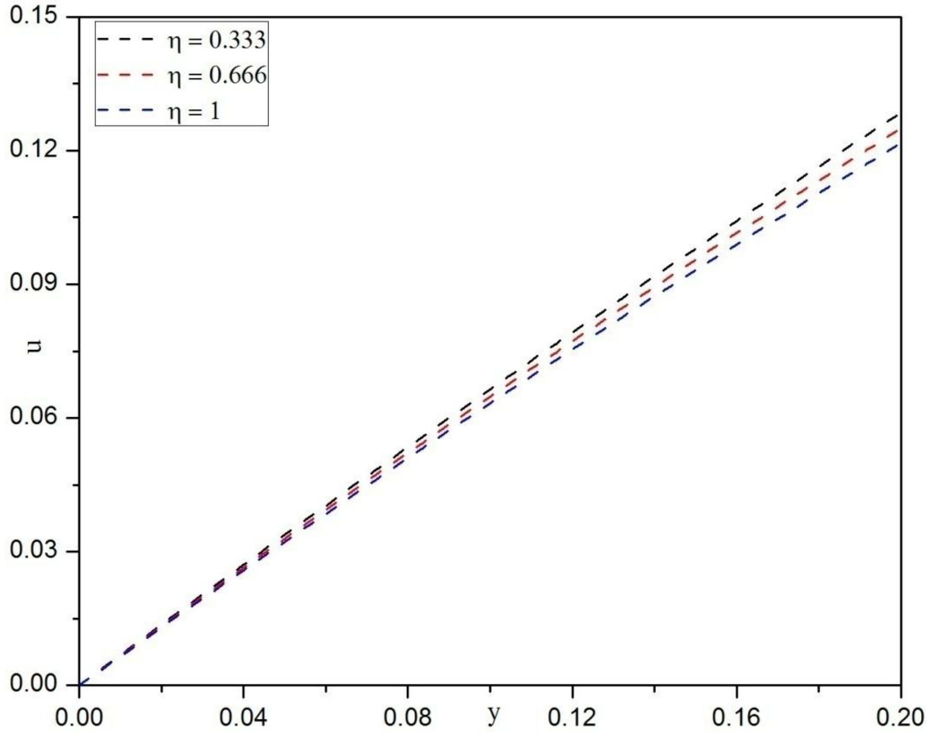

Figure 14: Deformable profiles for various estimations of η

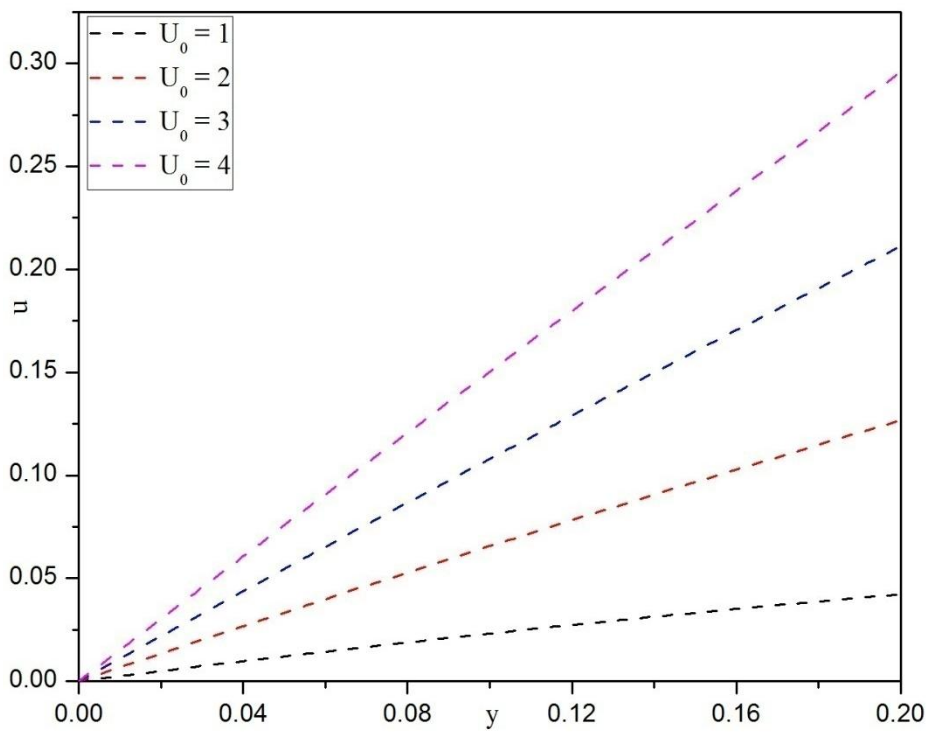

Figure 15: Deformable profiles for various estimations of U_0

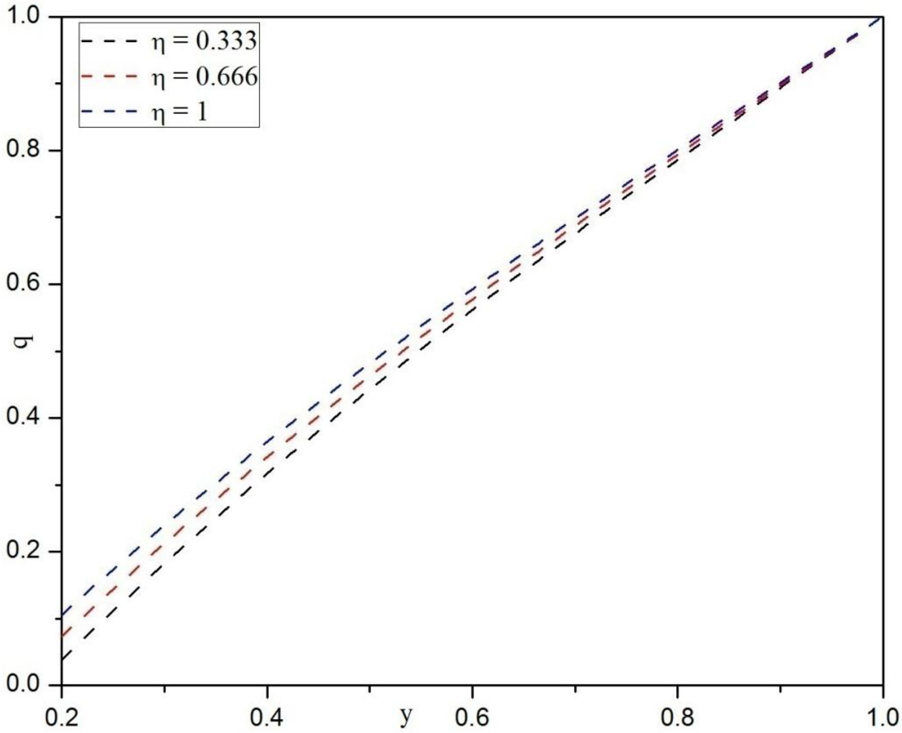

Figure 16: Deformable profiles for various estimations of η

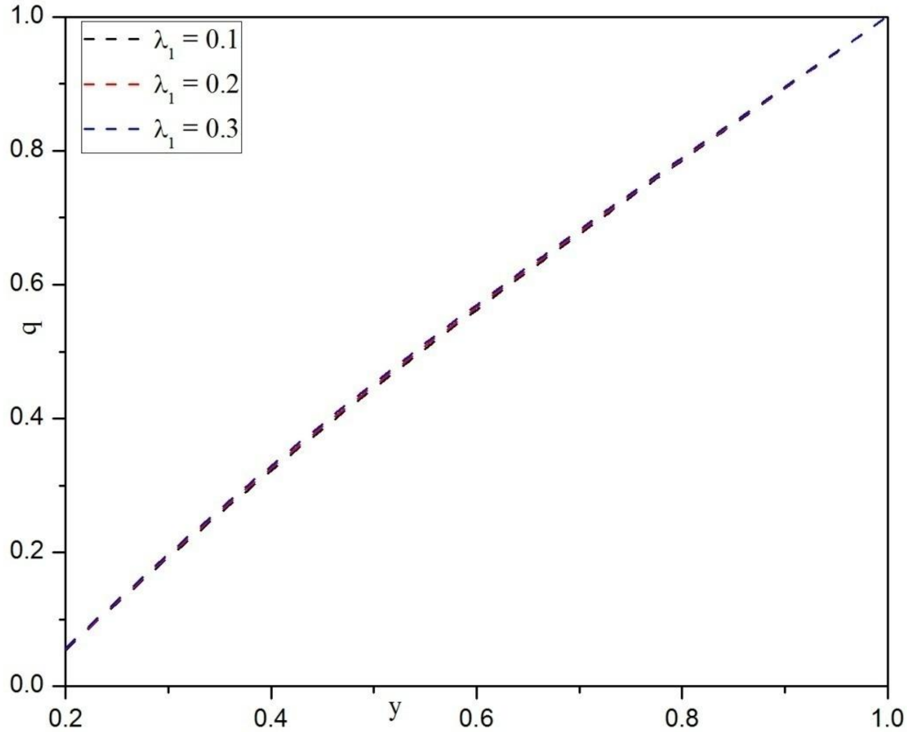

Figure 17Free stream profiles for various estimations of λ_1

ISSN: 1475-7192

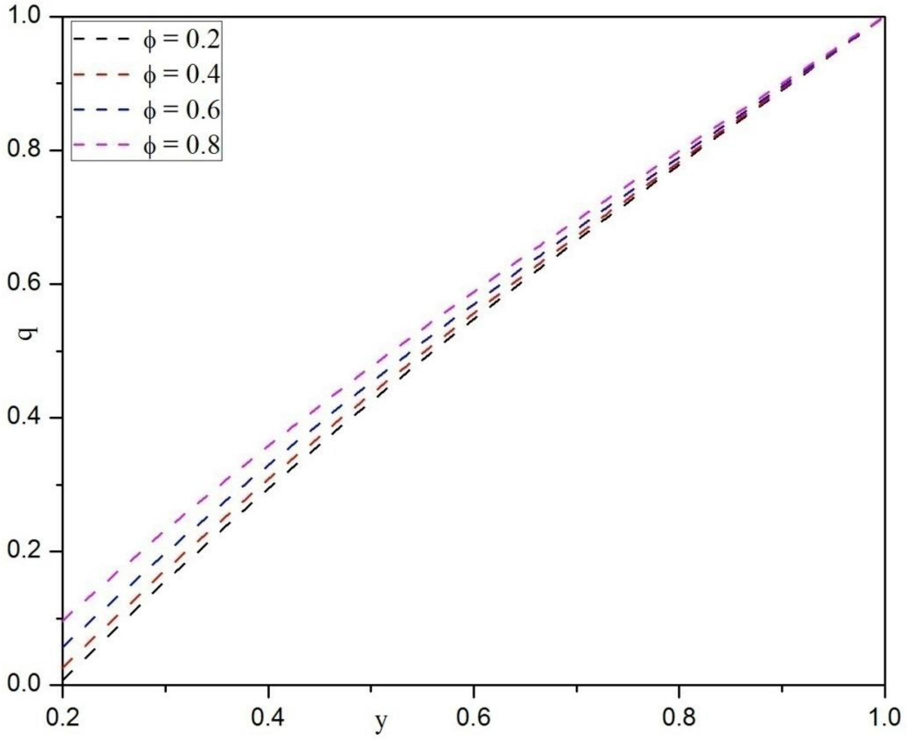

Figure 18: Free stream profiles for various estimations of ϕ

References:

1. Biot, M. A., General theory of three dimensional consolidation, J. Appl. Phys, 12(2) (1941) 155-164.
2. Maroudas, A., Physicochemical properties of cartelige in the light of ion exachnage theory, Biophy. J., 8, 575-594, 1968.
3. O. Iliev, A.Mikelic, P.Popov., On upscaling certain flows in deformable porous media, Multiscale Model. Simul., 7(1), 2008, 93-123.
4. Muri, H., The chemistry of the ground substance of joint cartilage, The joints and Synoval Fluid, II, ed., L. Sokoloff, Academic press, New York, 1980, 27-94.
5. Mow, V. C., Lai, W.M., Holmes, M. H., Advance theoretical and experimental techniques in cartilage Research, Biomechanics.
6. Edwards, J., Physical characteristics of artecular cartilage, Inst. Mech. Engrs., Proc. 181:16-24, 1967.
7. Linn, F. C., and L. Sokoloff ., Movement and composition of interstitial fluid of cartilage, Arthritis Rhrumat., 8:481-494,1964.
8. Mow VC, Holmes MH, Lai M. Fluid transport and mechanical properties of articular cartilage: a review, J. Biomechanics., 1984; 17: 377-394.
9. Oomens C.W.J, Van Campen D.H, and Grootenboer H.J., A mixture approach to the mechanics of skin, J. Biomech., 20, 877-885, (1987)
10. Yang M, and Taber L.A, The possible role of poroelasticity in the apparent viscoelastic behavior of passive cardiac muscle, J. Biomech., 24, 587-597, (1991)
11. Huyghe J.M, Van Campen D. H, Arts T and Heethaar R.M, A two-phase finite element model of the diastolic left ventricle, J. Biomech.,. 24, 527-538, (1991)

12. Kenyon D.E, A mathematical model of water flux through aortic tissue, Bull.Math. Biol., 41, 79-90, (1979)
13. Jayaraman G, Water transport in the arterial wall - a theoretical study, J. Biomech., 16, 833-840, (1983)
14. Klanchar M and Tarbell J. M, Modelling water flow through arterial tissue, Bull. Math.Biol., 49, 651-749, (1987)
15. Barry S I, Parker K H, Aldis G K. Fluid flow over a thin deformable porous layer, J. Appl. Math. Phy., 1991; 42: 693-578.
16. Ranganatha, T. R., Siddagamma, N. G., Flow of Newtonian fluid a channel with deformable porous walls, Proc. of National Conference on Advances in fluid mechanics, 2004, 41-77.
17. Sreenadh S, Krishnamurthy M, Sudhakara E, Gopi Krishna. G., Couete flow over a deformable permeable bed, Int. J. Innovative Res. Sci. & Eng., 2014 2547-3607.
18. Sreenadh, S., Vaidya, H.M., Sudhakara, E., Gopi Krishna, G., Krishnamurthy, M., MHD Couette flow of a Jeffery fluid over a deformable porous layer, Int. J. Appl.Comput. Math, 2016. DOI:10.1007/s40829-016-0222-1.