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# The Velocity, Temperature and Concentration Profiles for Triple Diffusive Casson Fluid Flow Subjected to the Soret-Dufour Parameters

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**ABSTRACT**

The triple-diffusive convection with the involvement of non-Newtonian fluid has many applications in the science and technology field, industrial processes, and also in research works. Therefore, the mathematical model of the triple-diffusive convection of Casson fluid by the mathematical approach is investigated. In addition, a mathematical model for the triple-diffusive convection of Casson fluid flow beyond a nonlinear compressing sheet has been formulated and solved by numerical approach, where this is the main objective of this study. This model is subjected to mass transfer and heat transfer, known as Soret and Dufour effect (Soret-Dufour). The Soret effect is occurred when the temperature gradient is produced, whereas the differences in mass cause the Dufour effect. The model is formed by the continuity equation, momentum equation, energy equation, and concentration equations of component 1 and 2, together with the boundary conditions. They have been reduced to ordinary differential equations, and subsequently, they have been implemented in bvp4c programme provided by MATLAB software to get the numerical solutions. The solutions obtained were profiles of velocity, temperature and concentration of both components. Next, the effect of Casson parameter, Soret parameter, and Dufour parameter have been investigated by changing their values of inside the coding in MATLAB and observing the behaviour of the related profiles due to these parameters. The main results from this study were: The velocity of the Casson fluid reduced as the Casson parameter enhanced, increment in both Soret and Dufour parameters caused the temperature to decrease, and the fluid concentration was higher for the increasing Soret number.

## 1. Introduction

The convective flow of non-Newtonian fluid plays vital role in industries, chemical engineering and also in many biological processes. Due to undeniable applications in medical field, metallurgy, and chemical engineering, non-Newtonian Casson fluid is being reported by many researchers recently. Meanwhile, the fluid flow induced by a compressing or extending sheet is highly related to

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many technological processes. Pramanik [1] studied the characteristic of a pseudo-plastic liquid owned by Casson fluid. When the rate of shear is zero, Casson fluid is assumed to have viscosity which is infinity. Contrastly, when the rate of shear is infinity, the viscosity becomes zero. The Casson fluid bounded by an extending sheet have been reported due to the additional impacts such as magnetic field [2-4], chemical reaction [2], viscous dissipation [2], various thermal conductivity [2], Soret-Dufour [3], internal heat generation [5] and so on. The pioneer publication of the numerical analysis on the Casson fluid flow bounded by a compressing sheet is authored by Bhattacharyya [6]. The recent studies due to the Casson fluid flow beyond the compressing or extending sheet are published with the details mathematical analysis [7-14].

Double-diffusive convection is induced when the there are when there is a significant difference between two values of the temperature and concentration distributions [15]. This type of convection is crucial in areas like oceanography [16]. Hence, many researchers have studied the involvement of double-diffusive convection in the fluid flow induced by extending/compressing sheet. In 2017, the free double-diffusive convection and mixed double-diffusive convection are considered by Kumar *et al.* [16] and Patil *et al.* [17], respectively. The effects of heat and mass transfer on the mixed double-diffusive convection have been considered for the various types of fluid: Newtonian [18-19], Maxwell [20-21], and Casson [8-9].

Triple-diffusive convection is the fluid flow in which the density depends on three diffusive components with no similar properties (thermal diffusion and dual species/components diffusion). The supreme utilization of this type of convection can be seen in warming of stratosphere [22]. Researchers are starting to pay attention to this convection as this is the first step in order to explore convection with more than three components. The experimental study of the triple-diffusive convection is performed by saturating a porous horizontal layer with the fluid mixture, heating the mixture from below and adding salt from above and below [23]. The triple-diffusive convection in a nanofluid over an extending sheet with nonlinear velocity was studied by Goyal and Bhargava [24]. Subsequently, the numerical study of the triple-diffusive convection in a Casson fluid and Eyring-Powell nanofluid over an extending sheet was reported by Archana *et al.* [25] and Khan *et al.* [26], respectively.

Based on the previous studies as above, there is no publications for the fluid flow over a compressing sheet for the case of triple-diffusive flow. The ultimate goal of this study is to solve a mathematical model of the triple diffusive Casson fluid flow over a nonlinear compressing sheet subjected to the Soret-Dufour effects. Thermo-diffusion or Soret effect is defined as the transfer of mass created by the temperature difference. Besides, the diffusion-thermo or Dufour effect shows the occurrence of heat transfer process due to mass difference.

## 2. Methodology

The incompressible Casson fluid flow through a horizontal compressing sheet is considered to be steady, laminar and free convection. The mathematical formulation in this study, is extended from Archana et al. [25] from the case of horizontal flat sheet to the new case: compressing flat sheet. The Casson fluid contains two different components with no similar properties. The mixture of these components in the fluid are assumed to be homogeneous and is in local thermal equilibrium. Component 1 and component 2 having different concentrations $C_1$ and $C_2$ respectively. Since the temperature at surface varies from temperature of surrounding air, Oberbecke-Boussinesq approximation is applied. The graphical ilustration of this problem is presented in Figure 1. From Figure 1, the compressing sheet is inclined with an angle of $\omega$ from the fixed vertical axis. The velocity in $x-$ and $y-$ axes is denoted by $u$ and $v$. The velocity in the direction of shrinking sheet is