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Applications of a Group Theoretical Method on Biomagnetic Fluid Flow and Heat Transfer for Different Shapes of Fe_3O_4 Magnetic Particles under the Influence of Thermal Radiation and a Magnetic Dipole over a Cylinder

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Abstract: The flow and heat characteristics of an unsteady, laminar biomagnetic fluid, namely blood containing Fe_3O_4 magnetic particles, under the influence of thermal radiation and a magnetic dipole over a cylinder with controlled boundary conditions using a group theory method are investigated in the present study. The mathematical formulation of the problem is constructed with the aid of biomagnetic fluid dynamics (BFD) which combines principles of ferrohydrodynamics (FHD) and magnetohydrodynamics (MHD). It is assumed that blood exhibits polarization as well as electrical conductivity. Additionally, the shape of the magnetic particles, namely cylindrical and spherical, is also considered. Moreover, in this model, a group theoretical transformation, namely a two-parameter group technique, is applied. By applying this group transformation, the governing system of partial differential equations (PDEs) along with applicable boundary conditions are reduced to one independent variable and, consequently, converted into a system of ordinary differential equations (ODEs) with suitable boundary conditions. An efficient numerical technique is applied to solve the resultant ODEs and this technique is based on three essential features, namely (i) a common finite differences method with central differencing, (ii) tridiagonal matrix manipulation and (iii) an iterative procedure. The flow and heat characteristics of blood-Fe_3O_4 are found to be dependent on some physical parameters such as the particle volume fraction, the ferromagnetic interaction parameter, the magnetic field parameter, and the thermal radiation parameter. An ample parametric study is accomplished to narrate the influences of such physical parameters on velocity, temperature distributions as well as the coefficient of skin friction and rate of heat transfer. From the numerical results, it is deduced that the fluid velocity is enhanced for the ferromagnetic number and the temperature profile is decreased as the ferromagnetic number is gradually increased. It is also obtained that for the cylindrical shape of magnetic particles, the fluid temperature is more enhanced than that of the spherical shape. Both the skin friction coefficient and the local Nusselt number are increased for increasing values of the ferromagnetic interaction parameter, where the heat transfer rate of blood-Fe_3O_4 is significantly increased by approximately 33.2% compared to that of pure blood, whereas the coefficient of skin friction is reduced by approximately 6.82%.

Keywords: group theoretical method; biomagnetic fluid dynamics (BFD); blood; magnetic particles; cylinder; magnetic dipole; finite differences method

MSC: 35Q35; 76M20; 76M55; 76W05

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