# Title: Analytical Investigation of Heat Transfer in Natural Convection of Nanofluids Under the Influence of Induced Magnetic Fields, Heat Sources, and Radiative Effects.

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## ABSTRACT:

This analysis investigates heat transfer via natural convection between two vertical insulated walls, incorporating effects from radiative heat flux, induced magnetic fields, and heat sources in the presence of nanofluids. By solving the dimensionless coupled governing equations, the study derives analytical expressions for temperature distribution, velocity field, and induced magnetic field. It examines the influence of these non-dimensional parameters on skin friction and the Nusselt number within nanofluid contexts. The obtained results are compared with the existing result with good agreement.

## AIM OF THE RESEARCH:

In this work, we analyze the MHD flow for natural convection with radiative effects, an induced magnetic field, and a heat source in the presence of a nanofluid. The results are examined analytically and supported by graphical analysis.

## INTRODUCTION:

Nanofluids and Magnetohydrodynamics (MHD) are two advanced techniques used to enhance heat transfer in various applications. Nanofluids are fluids that contain nanoparticles suspended in them. These nanoparticles are typically made from materials like metals, oxides, or carbon-based substances. They are commonly used in cooling systems for electronic devices, including CPUs and GPUs. The enhanced thermal conductivity of nanofluids helps dissipate heat more efficiently than conventional coolants. In engine cooling systems and radiators, nanofluids can improve heat transfer performance, which helps in better engine cooling and reduces the risk of overheating. Nanofluids are employed in heat exchangers to increase the heat transfer rate. This is particularly useful in industries where efficient heat exchange is crucial, such as in chemical processing. Nanofluids can be used in solar collectors to enhance the efficiency of heat transfer from the collector to the heat storage or distribution system. This helps in improving the overall performance of solar thermal systems. In petroleum engineering, nanofluids are used to improve the efficiency of oil extraction processes by enhancing heat transfer during steam injection.

Magnetohydrodynamics involves the study of the behavior of conductive fluids in the presence of a magnetic field. This field of study can affect the flow and heat transfer characteristics of the fluid. In advanced nuclear reactors and some high-performance cooling systems, liquid metals (like sodium or mercury) are used as coolants. MHD can help manage the flow of these conductive liquids to improve heat transfer and stability. MHD is crucial in fusion reactors, where magnetic fields are used to confine the hot plasma. Understanding MHD helps in optimizing the magnetic confinement to maintain stable and efficient plasma conditions. These pumps use the interaction between a magnetic field and a conducting fluid to create motion. They are used in various applications, including cooling systems and certain chemical processing systems, where traditional mechanical pumps might not be ideal. MHD techniques are applied to control fluid flow in various systems, such as in metallurgical processes and in aerospace applications, where precise control of fluid dynamics is required. MHD is also relevant in space technology, such as in the design of propulsion systems and in the management of thermal conditions in spacecraft.

Considering the applications mentioned, this study investigates the combined effects of nanofluids and MHD. By using both nanofluids and magnetic fields together, we aim to maximize heat transfer efficiency. For instance, in specific experimental setups or specialized cooling systems, the interaction between nanofluids and magnetic fields can significantly enhance thermal performance and flow characteristics.In summary, nanofluids and MHD represent sophisticated approaches to improving heat transfer in various technological and industrial applications, providing significant benefits in terms of efficiency and performance.

With the above motivaton the present study proposes to analyze the steady-state magnetohydrodynamic convection heat transfer of a Newtonian, viscous, incompressible, electrically conducting radiative fluid flowing past a vertical plate in the presence of nanofluid. The analysis considers the effects of radiation absorption, as well as the influence of an induced magnetic field, volume fraction of the magnetic field.

**FORMULATION OF THE PROBLEM:**

The governing equations for the flow problem are modelled as follows:

$$\nabla . \boldsymbol{q} = 0$$

$$\rho(\boldsymbol{q} . \nabla)\boldsymbol{q} = -\nabla p + \mu(\nabla^2 \boldsymbol{q}) + (\boldsymbol{J} \times \boldsymbol{B}) + \rho g$$

$$(\nabla^2 \boldsymbol{H}) + \nabla \times (q \times \boldsymbol{H}) = 0$$

$$(q . \nabla)T = \frac{k}{\rho C_p}\nabla^2 T + \frac{Q(T - T_0)}{\rho C_p} - \frac{1}{\rho C_p}\nabla . \boldsymbol{q_r}$$

**METHODOLOGY:**

The above problem is analyzed analytically using the simultaneous ODEs theory.

**RESULTS:**

1. The impact of the thermal radiation parameter enhances the velocity, induced magnetic field in the presence of nanoparticles.

2. Temperature field profiles are to increase with radiation as well as Newtonian heating effect but reduces with Newtonian cooling in presence of nanofluids.

3. Nusselt number increases with radiation parameter and Newtonian heating parameter at both walls whereas decreases with the Newtonian cooling parameter in presence of nanofluids.

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