

## Abstract

The urgent challenge of climate change calls for innovative energy solutions that reduce greenhouse gas emissions and strengthen system resilience. Solar thermal technology, when enhanced by advanced fluid dynamics, offers a promising pathway towards sustainable clean energy. This study simulates the performance of hybrid nanofluids, specifically copper and titanium dioxide nanoparticles dispersed in water, to improve heat transfer efficiency in parabolic solar thermal collectors. The governing nonlinear partial differential equations describing mass, momentum, energy, concentration, and magnetic induction are reduced to ordinary differential equations using similarity transformations and solved using MATLAB's collocation based `bvp4c` solver. The model assumes two-dimensional laminar flow, thermal equilibrium between fluid phases, and temperature dependent hybrid nanofluid properties. Parametric analysis shows that Brownian diffusion and thermophoresis significantly influence velocity, temperature, and nanoparticle concentration, while Prandtl and thermal Grashof numbers strongly govern convective transport and MHD coupling. The findings provide deeper physical insight into hybrid nanofluid dynamics under electromagnetic influences and support the optimization of solar thermal collectors for enhanced thermal performance. The study contributes to Sustainable Development Goals 13 by advancing efficient and climate resilient clean energy technologies.