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THE POWER OF SCIENTIFIC INNOVATION

INTELLIGENT SOLUTIONS FOR A SUSTAINABLE WORLD

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PREFACE

Welcome to the 2nd International Science, Engineering and Technology Colloquium 2025 (ISETC 2025)!

It is with great pleasure that we present this year's colloquium, a distinguished gathering of scholars, researchers, and professionals dedicated to the advancement of applied sciences. Held virtually on 9th July 2025, ISETC 2025 serves as a platform to highlight cutting-edge research, foster meaningful networking, encourage collaborations, and explore innovative solutions to global challenges.

This year's theme, "The Power of Scientific Innovation: Intelligent Solutions for a Sustainable World" highlights our shared goal to solve global challenges through applied science. It celebrates innovation as a key to building a more sustainable and resilient future. We're proud to feature keynote speakers and presenters who bring fresh insights, bold ideas, and breakthroughs shaping tomorrow's world.

We would like to extend our heartfelt appreciation to the Faculty of Applied Sciences, Universiti Teknologi MARA, Perak Branch, Tapah Campus, for their outstanding support and assistance throughout the planning and execution of the event. Their dedication has been instrumental to the success of this colloquium. We would like to sincerely thank all participants and researchers for their valuable contributions. We also appreciate the reviewers for their careful evaluations and helpful feedback. Your hard work and support mean a lot to us.

As editors, we are proud to present this collection of proceedings. It is an honour to bring together the interesting and meaningful work of our speakers and authors. We hope the ideas shared will lead to new discoveries, encourage more research, and help solve global challenges through science and innovation.

Warm regards,

Dr. Emi Norzehan Mohamad Mahbob
Dr. Saiyidah Nafisah Hashim
Ms. Lili Widarti Zainuddin
Ms. Nurul Nazwa Mohammad
Ms. Rozaina Saleh

ISETC 2025 Proceedings Editors

ENHANCED THERMAL CONDUCTIVITY OF SPHERICAL GRAPHENE-BASED NANOFLUID FLOW NEAR A STAGNATION POINT IN A MICROGRAVITY ENVIRONMENT

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Abstract: This study presents a theoretical investigation of three-dimensional unsteady nanofluid flow with enhanced thermal conductivity using spherical graphene nanoparticles near a stagnation point under microgravity environment. A mathematical model is formulated to describe the conservation of mass, momentum, and energy, resulting in a coupled system of nonlinear partial differential equations. The governing equations are transformed using appropriate semi-similar variables and solved using the Keller box method, a robust finite difference-based numerical technique well-suited for boundary layer problems. Analysis is conducted to examine the influence of nanoparticle volume fraction, curvature ratio and g-jitter effect on flow behaviors and thermal characteristic of the fluid system. The results reveal that the inclusion of spherical graphene nanoparticles significantly enhances the effective thermal conductivity, leading to improved heat transfer rates. The findings provide valuable insight for the optimization of thermal management systems in microgravity applications such as spacecraft and other microgravity environment condition.

Keywords: *Boundary layer flow, nanofluid, stagnation point, g-jitter, heat transfer*

INTRODUCTION

Nanofluids, formed by dispersing nanoparticles in traditional base fluids, have attracted considerable attention for their enhanced thermal properties, especially their capacity to improve heat transfer efficiency in engineering applications. In boundary layer flows, nanofluids demonstrate enhanced thermal conductivity and convective heat transfer rates, rendering them suitable for improved thermal regulation systems. Recent studies have examined several nanoparticles, including metal oxides, pure metals, and carbon-based materials, with graphene identified as a possible possibility due to its remarkable thermal conductivity and mechanical durability (Sundar et al., 2021; Alawi et al., 2023). The behaviour of nanofluids at stagnation points is particularly significant, as these areas exhibit intricate fluid dynamics and heat gradients. Research indicates that nanoparticles substantially alter the velocity and temperature boundary layers in stagnation point flows, especially in unstable and three-dimensional scenarios (Ramesh et al., 2022; Ezzat et al., 2024). Tiwari and Das (2007) examined the augmentation of heat transfer through nanofluids in a differentially heated square chamber with dual sliding lids, emphasising the contribution of nanoparticles to the improvement of natural convection. Buongiorno (2006) presented a fundamental model for convective transport in nanofluids, highlighting the significance of nanoparticle dynamics and suggesting alternate processes to elucidate the observed enhancements in heat transfer rates.

In microgravity situations, a significant issue in fluid flow research is the phenomena of g-jitter—slight, random accelerations produced by mechanical systems or crew activities within spacecraft. These perturbations can profoundly influence fluid dynamics around stagnation points, undermining the stability of thermal and mass transfer processes. The examination of g-jitter's interaction with nanofluid systems is nascent, with an increasing volume of research exploring the effects of such disturbances on heat transfer in nanoparticle-infused fluids (Wu et al., 2021; Mahapatra & Motsa, 2023). Research indicates that g-jitter can disrupt temperature gradients and impair flow homogeneity, especially in vulnerable areas such as stagnation regions. Based on the literature and significant of nanofluid in boundary layer flow, a theoretical investigation is conducted on unsteady, three-dimensional stagnation point flow of a spherical graphene-based nanofluid in microgravity. The acquired insights seek to enhance thermal management systems in aircraft applications, where reliable and efficient heat control is crucial.

MATHEMATICAL FORMULATION

An unsteady free convection nanofluid flow near a three-dimensional stagnation point region under microgravity environment was studied theoretically with spherical graphene considered as nanoparticles. Based on physical law and principle, the system of partial differential equation (PDE) that govern the fluid system formulated such in dimensional form. Due to limited space, this study only presenting the dimensionless form of PDE that presenting the fluid setup such that,

$$\left(1-\phi+\phi\frac{\rho_s}{\rho_f}\right)\left[\Omega\frac{\partial f'}{\partial\tau}-(f+h)f''+f'^2\right]=\frac{f'''}{(1-\phi)^{2.5}}+\left[1-\phi+\frac{\phi(\rho\beta_t)_s}{(\rho\beta_t)_f}\right]\left[1+\varepsilon\cos(\pi\tau)\right], \tag{1}$$

$$\left(1-\phi+\phi\frac{\rho_s}{\rho_f}\right)\left[\Omega\frac{\partial h'}{\partial\tau}-c(f+h)h''+ch'^2\right]=\frac{h'''}{(1-\phi)^{2.5}}\left(1+\frac{1}{\beta}\right)+\left[1-\phi+\frac{\phi(\rho\beta_t)_s}{(\rho\beta_t)_f}\right]\left[1+\varepsilon\cos(\pi\tau)\right], \tag{2}$$

$$\frac{1}{\Pr}\left[\frac{\left(k_s-2k_f\right)-2\phi\left(k_f-k_s\right)}{\left(k_s-2k_f\right)+\phi\left(k_f-k_s\right)}\right]\theta''+\left[(1-\phi)+\frac{\phi\left(\rho C_p\right)_s}{\left(\rho C_p\right)_f}\right](f+h)\theta'=\Omega\left[(1-\phi)+\frac{\phi\left(\rho C_p\right)_s}{\left(\rho C_p\right)_f}\right]\frac{\partial\theta}{\partial\tau}, \tag{3}$$

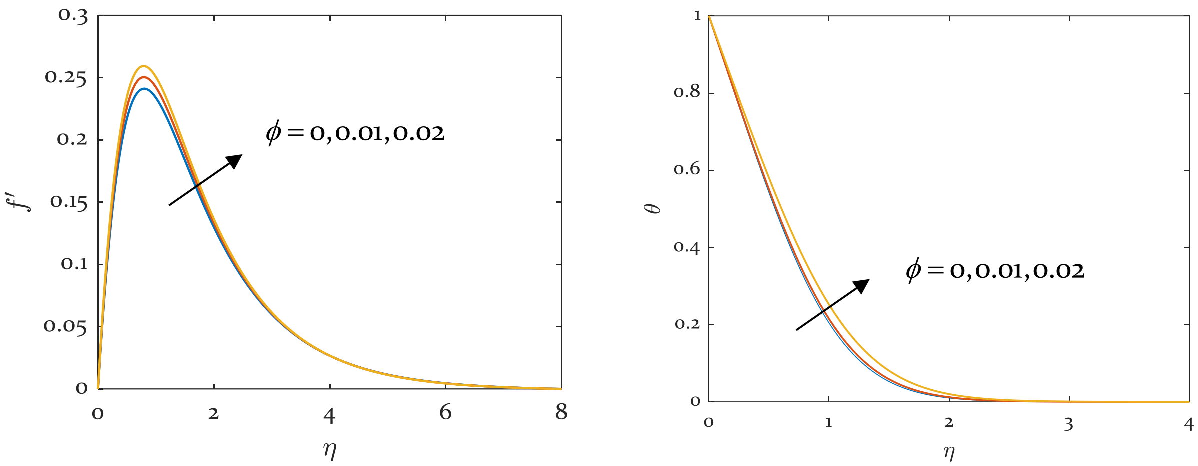
subject to

$$f(\eta,0)=f'(\eta,0)=h(\eta,0)=h'(\eta,0)=0,\quad \theta(\eta,0)=1,\ f'\to 0,\ h'\to 0,\ \theta\to 0,\quad \text{as}\quad \eta\to\infty \tag{4}$$

The thermophysical properties of the nanofluid are carried by $\rho,\ \mu,\ \beta\ \alpha$ and C_p denote the density, dynamic viscosity, thermal expansion, thermal diffusion, and specific heat capacity at constant pressure. Here, ϕ is defined as the nanoparticle volume fraction which is the concentration of the nanoparticles that is added into the fluid and k is defined as the thermal conductivity. The subscript f and s represent the fluid and solid component in the nanofluid mixture respectively. The system of dimensionless PDE then solved numerically using finite different scheme known as Keller box method. The effect of spherical graphene added into the fluid system are analyzed graphically in the next section.

RESULTS AND DISCUSSION

Theoretical study on free convection nanofluid flow near a three-dimensional stagnation point region was conducted with spherical graphene are considered. The thermophysical values of the nanoparticles applied and the based fluid was taken from Reyaz et al (2025). One of the effects considered with the presence of nanoparticle in the fluid system is nanoparticle volume fraction, ϕ. The effect of ϕ were analyzed on velocity and temperature profile as shown in Figure 1(a) and Figure 1(b). In addition, Table 1 shown the effect of ϕ on skin friction on $x-$ and $y-$directions presented by symbol $C_{fx}/Gr^{3/4}$ and $C_{fy}/Gr^{3/4}$ respectively while $Nu/Gr^{1/4}$ denoted as the Nusselt number. An increasing behavior is noticed in both velocity and temperature profiles. This is because graphene has very high thermal conductivity, which helps the fluid absorb and transfer heat more efficiently. As more nanoparticles are added, the nanofluid becomes better at conducting heat, resulting in a higher temperature profile. At the same time, the improved thermal energy increases buoyancy forces, which enhances the fluid motion and thus increases the velocity. Overall, the presence of more graphene nanoparticles improves both the heat transfer and flow characteristics of the fluid. On the other hand, the study also reveals that increasing of ϕ leads to an increases in $C_{fx}/Gr^{3/4}$, $C_{fy}/Gr^{3/4}$ and $Nu/Gr^{1/4}$. The rise in $C_{fx}/Gr^{3/4}$ and $C_{fy}/Gr^{3/4}$ is due to the higher viscosity of the nanofluid caused by the added nanoparticles, which increases resistance near the surface. At the same time, the enhanced thermal conductivity of graphene improves heat transfer at the boundary, resulting in a higher $Nu/Gr^{1/4}$. This indicates that the nanofluid with more graphene particles is more effective at transferring heat from the surface to the fluid. Overall, the inclusion of graphene nanoparticles intensifies both shear forces at the wall and the convective heat transfer rate.



(a) (b)

Figure 1. Effects of ϕ on velocity profile in (a) $x-$ and (b) $y-$directions

Table 1. Effects of ϕ on skin frictions and Nusselt number

ϕ	$C_{fx} / Gr^{3/4}$	$C_{fy} / Gr^{3/4}$	$Nu / Gr^{1/4}$
0	0.5422	0.2796	0.8501
0.01	0.5812	0.2998	0.8777
0.02	0.6207	0.3203	0.9046

CONCLUSIONS

In this theoretical study, a three-dimensional unsteady nanofluid flow near a stagnation point under a microgravity environment was investigated using mathematical modeling. Spherical graphene nanoparticles were introduced to enhance the thermal conductivity of the base fluid. The governing equations for momentum and energy were successfully formulated and analyzed to describe the behavior of the fluid system. The results showed that increasing the volume fraction of graphene nanoparticles led to significant enhancements in the velocity and temperature profiles, as well as in skin friction and the Nusselt number. These findings highlight the effectiveness of graphene nanoparticles in improving both flow and heat transfer characteristics, especially in microgravity conditions where conventional convection is limited. The developed model provides a useful foundation for future studies and practical applications in advanced thermal management systems.

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