# DECLARATION

I, **Neethu T S**, hereby declare that the thesis entitled, "Flows of Nanofluids Past Plates and in Channels", submitted to the University of Calicut in partial fulfillment of the requirements for the award of the Degree of Doctor of Philosophy in Mathematics is a bonafide research work done by me under the supervision and guidance of Dr. Alphonsa Mathew, Assistant Professor, Department of Mathematics, St. Thomas College (Autonomous), Thrissur, Kerala.

I further declare that this thesis has not previously formed the basis of any degree, diploma or any other similar title.

Thrissur

22 December 2022

**Neethu T S**

# CERTIFICATE

This is to certify that the thesis titled "**Flows of Nanofluids Past Plates and in Channels**" submitted by **Neethu T S** to University of Calicut in partial fulfilment of the requirements for the award of the Degree of Doctor of Philosophy in **Mathematics** is a record of original research work carried out by her under my supervision. The content of this thesis, in full or in parts, has not been submitted by any other candidate to any other University for the award of any degree or diploma.

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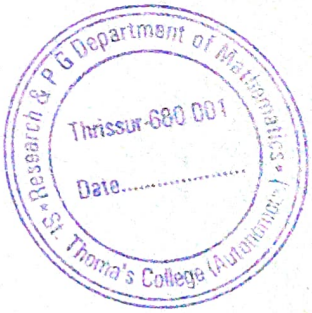

# CERTIFICATE

I hereby certify that, this is the revised version of the thesis entitled "**Flows of Nanofluids Past Plates and in Channels**" submitted by **Neethu T S** under my guidance, after incorporating the necessary corrections/ suggestions made by the adjudicators. I also certify that the contents in the thesis and the soft copy are one and the same.

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## ABSTRACT

The present thesis is attentive to the numerical investigation of viscous incompressible nanofluid flow past plates and in channels in the presence of an applied magnetic field under different conditions. Tiwari-Das nanofluid models are employed to describe fluid motion. This thesis is arranged into six chapters in which **Chapter 1** is an introductory one that contains some basic concepts, preliminaries, and background of the work. A review of relevant literature has also been included.

**Chapter 2** investigates the magnetohydrodynamic flow of water-based nanofluids between two oppositely moving vertical porous plates. The Perturbation technique is used to solve the governing equations of the flow. The consequence of various parameters on velocity, temperature, and concentration are examined via graphs utilizing MATLAB software. The physical quantities are scrutinized using statistical tools like probable error and multiple linear regression and an excellent agreement is noted. Furthermore, the simultaneous effects of parameters on drag coefficients are studied with the aid of three-dimensional surface plots.

**Chapter 3** explores the three-dimensional convective hydromagnetic hybrid nanoliquid (with suspended $Al_2O_3$ and $Fe_3O_4$ nanoparticles) flow between two oppositely moving vertical porous plates utilizing the Perturbation technique. The consequence of effectual parameters on the flow profiles is analyzed with the aid of graphs using MATLAB software. Further, the rate of heat transfer is statistically scrutinized utilizing RSM (Response Surface Methodology) and sensitivity analysis. Three-dimensional surface plots are made used to illustrate the parallel effect of pertinent parameters on the drag coefficient. Moreover, this study finds applications in several engineering, geophysical, and industrial fields in heat exchangers and faulting.

**Chapter 4** includes a theoretical investigation of bioconvective flow of electromagnetohydrodynamic (EMHD) hybrid nanofluid (water-based $CNT - Fe_3O_4$) over a stretching surface. The impact of viscous dissipation, chemical reaction, and stratification is also explored in it. The highly nonlinear system of partial differential equations (PDEs) is reduced to a system of ordinary differential equations

(ODEs) by effectual similarity transformations and then treated numerically using bvp4c (a finite difference-based built-in numerical procedure) in MATLAB. Further, the drag coefficient is statistically scrutinized for the impact of nanoparticle volume fraction of carbon nanotubes, the volume fraction of magnetite nanoparticles, the Hartmann number, and the electric field parameter by exercising the four-factor response surface methodology. This study finds applications in cancer therapy, bio-microsystems, biomedical imaging, and therapeutic drug delivery.

**Chapter 5** analyses the magnetohydrodynamics of bioconvective hybrid nanofluid (water-based $TiO_2 - Ag$ ) flow over a permeable exponential stretching sheet. The effects of thermal radiation, heat generation, chemical reaction, porosity, and viscous dissipation have been incorporated. Similarity transformations are applied to the nonlinear system of partial differential equations that arise by the flow. The nonlinear ordinary differential system hence obtained is solved by MATLAB built-in function bvp5c to visualize the role of effectual parameters via tables and graphs. Physical quantities of the fluid flow are scrutinized using 3D surface plots and tables. Further, the drag coefficient and heat transfer rate are scrutinized using statistical techniques, in which multiple linear regression analysis shows a good agreement of original data and estimated data, highlighting the reliability of the study. This study can apply to manufacture the most effective and qualified products in industries

**Chapter 6** presents the concluding remarks of the thesis and proposals for future work. These studies find applications in the biomedical field and industrial fields.

*To My Family*

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