

# 1. INTRODUCTION

The differential equation (PDE) is an equation that contains the derivative of the dependent variable on the independent variable. Differential equations are grouped into two types based on the number of independent variables, namely ordinary differential equations and partial differential equations. Based on linearity, there are 2 partial differential equations, namely linear partial differential equations and non-linear differential equations [1]. Partial differential equations (PDE) are widely used in several quantitative disciplines, from physics to economics, in an attempt to describe the evolution and dynamics of phenomena [2]. Examples of non-linear differential equations are the Burgers equation, the Fisher equation, the Liouville equation, and the Boussinesq equation (Wazwaz, 2009). The Fisher-Kolmogorov equation for the reaction-diffusion process discussed uses decomposition to determine concentration statistics [3]. The one-dimensional Fisher-Kolmogorov equation with density-dependent non-linear diffusion. The Fisher equation with non-linear diffusion is known as the modified Fisher equation. There have been many studies in numerical analysis to efficiently calculate the numerical solutions of PDEs using different finite volume methods and with various constraints on the domain boundaries. Because PDE has high dimensions, the computational costs are quite high, creating many challenges for applied mathematicians [4][5]. An increasing number of research studies use machine learning techniques, especially using deep learning algorithms. With deep learning algorithms, it is hoped that they can provide new horizons for calculating appropriate numerical solutions at considerable cost and computation time [6].

To account for equations that are linear combinations of physical functions, we interpolate the observed data using the Physics-Informed Neural Network (PINN) technique. The Physics-Informed Neural Network (PINN) technique is a technique that studies a type of universal function approach that can incorporate knowledge of all the physical laws that govern certain data sets into the learning process and can be explained by partial differential equations (PDE) [7]. The ability of Physics-Informed Neural Network (PINN) can overcome the lack of information from data by utilizing the laws of physics that underlie the system. Instead of studying purely with data monitoring, besides that, the PINN technique is also used in mathematical equations that govern existing physical phenomena [8]. The main advantage of PINN is that it uses known basic physical laws to govern the system. The known physical model provides additional information for the neural network to predict the behavior of the system within the domain rather than relying heavily on data feeds, which are not always available in large quantities [9].

Research conducted by Alexander M. Tartakovsky et al stated that the physics-based Deep Neural Network (DNN) method can accurately estimate non-linear constitutive relationships based on state measurements alone [10]. Meanwhile, Muhammad Shakeel researched the one-dimensional Fisher-Kolmogorov equation with density-dependent non-linear diffusion using COMSOL, resulting that the minimum wave velocity depending on the parameter values involved in the model [11]. Maziar Raissi etc. researched to solve differential equation problems using the Runge Kutta method [6]. The results of research by Aditya Firman Ihsan stated that the PINN method has the advantage that having more data can give better results but will consume more computation time and memory compared to the PDE numerical-solving method. Based on several previous studies, it was found that the PINN method has great potential to be a powerful method.

In this study implements the PDE solution on the Fisher Kolmogorov equation using the Physics-Informed Neural Network (PINN) technique. In this paper, the standard non-linear Fisher Kolmogorov equation is studied; namely a two-dimensional finite domain with the condition of using location ( $x$ ) for boundary conditions and time ( $t$ ) for initial conditions. Moreover, we apply PINN to solve them and analyze their performance. The standard numerical solution with a finite difference scheme is used as a comparison for the solution obtained by PINN. The results obtained in this study can be used as a consideration for the application of the PINN method in the future, especially when compared to other numerical methods that are already widely used. So it can be said that the function proves to be correct if the results of the experiment are consistent several times using the same parameters.