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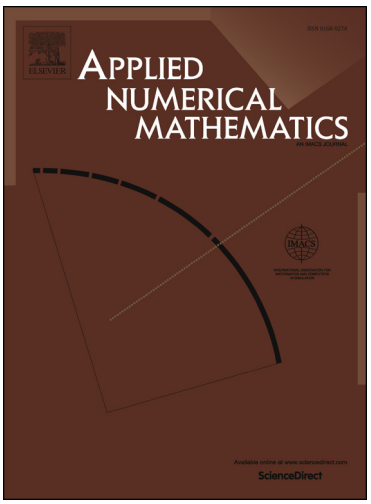

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Ömür Kıvanç Kürkçü, Ersin Aslan, Mehmet Sezer

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A numerical method for solving some model problems arising in science and convergence analysis based on residual function

Ömür Kıvanç Kürkçü[a,*], Ersin Aslan[b], Mehmet Sezer[a]

[a]Department of Mathematics, Faculty of Science, Manisa Celal Bayar University, Manisa 45140, Turkey, e-mail: omurkivanc@outlook.com, mehmet.sezer@cbu.edu.tr
[b]Turgutlu Vocational Training School, Manisa Celal Bayar University, Manisa, Turkey, e-mail: ersin.aslan@cbu.edu.tr,
*Corresponding author e-mail: omurkivanc@outlook.com

Abstract
In this study, we solve some widely-used model problems consisting of linear, nonlinear differential and integral equations, employing Dickson polynomials with the parameter-α and the collocation points for an efficient matrix method. The convergence of a Dickson polynomial solution of the model problem is investigated by means of the residual function. We encode useful computer programs for model problems, in order to obtain the precise Dickson polynomial solutions. These solutions are plotted along with the exact solutions in figures and the numerical results are compared with other well-known methods in tables.

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Keywords: Collocation points; Convergence; Dickson polynomials; Matrix method.

1. Introduction

Model problems containing differential and integral equations have played an important role broadly in mathematics, physics, biology and engineering since their early years. It is usually hard to find the analytical solutions of these problems. Therefore, efficient numerical methods investigating the behavior of the approximate solutions have been introduced. Some of which are the matrix collocation based on the polynomials [1-6], Adomian's decompositon [7], He's homotopy perturbation [8] and He's variational iteration methods [9]. The permutation Dickson polynomials [10,11] we will employ in this study for a matrix method contain a parameter-α. For more consistency in approximations, we can change a obtained solution by means of this parameter.

Our aim in this study is to efficiently and rapidly solve some widely-used model problems, by obtaining the Dickson polynomial solutions approaching to the exact solution of these problems. As well as using the different parameter-α in the Dickson polynomial solutions, we also investigate the convergence of these solutions via the residual function in Banach space. The general form of some model problems we will consider in this study can be written as

$$L\left[y(t)\right]+N\left[y(t)\right]=g(t),\ a\le t\le b, \tag{1}$$