Numerical Solution of the Duffin's Equation based on 4th Order Runge-Kutta Solver.

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Abstract: The Duffin's equation arises in the motion of a simple pendulum. It's been presented considering a Taylor's series approximation of the first few terms in the sine series. Based on this approximation, a few numerical values is presented for the numerical solution of the differential equation based on one of the ODE solver, fundamentally 4th order Runge-Kutta based.
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Key words: Duffin's equation, Runge-Kutta method, Taylor's series, ODE 45 solver.

1. Introduction

Differential equation arises in diverse number of systems and application in dynamical systems,

etc. Precisely, the numerical solution of the Duffin's equation is considered based on the ODE 45 solver, and subject to a requisite initial condition.

The 4th order Runge-Kutta method has been extensively applied in diverse fields of applications in physical science, applied mathematics, etc, and obviously opened a broad spectrum of researches for enhancement of the numerical performance. Some modifications have emerged, like the Adam-Bashforth, Milne's predictor-corrector methods, etc.

2. Discussion

The Duffin's equation arises out of the motion of a pendulum, it is expressed as;

$$\breve{\phi} + a\sin\phi = c\cos t,\ \phi(0) = \phi(\pi) = 0.$$

The differential equation has an integral equivalent or equation representation viz;

$$\phi(t) - \int_0^t (t-y)\left\{a(\phi(y)) - \frac{1}{6}\phi^3(y)\right\}dy = ct$$

,where c is the unknown value of $\phi'(0)$which is called the shape parameter.

Based on the Taylor's series approximation, sinϕ is replaced by; $\phi - \frac{1}{6}\phi^3$ for the first few terms.

3. Result

y=	ϕ=
0	1.0000
0.0125	0.9979
0.0375	0.9915
0.0500	0.9893
0.0625	0.9872
0.0750	0.9850
0.0875	0.9828
0.1000	0.9806
0.1125	0.9784
0.1250	0.9762
0.1375	0.9740
0.1500	0.9717
0.1625	0.9695
0.1750	0.9673
0.1875	0.9657
0.2000	0.9629

4. Conclusion

The numerical result of the Duffin's equation has been presented for few values based on the 4th order Runge-Kutta method, having applied the Taylor's series approximation analytically for approximating few first terms of the sine series.

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