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Some results on undamped force vibrations of a spring using numerical methods

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Abstract
In this paper have been discussed the numerical technical solutions for some undamped force vibrations of a spring problem using well-known numerical methods such as Runge-Kutta fourth order classical method and Eulers Modified Method.

Keywords: Undamped forces, differential equations, numerical methods

1. Introduction
From last few decades considerable efforts have been made using some techniques towards the development of computational methods to solve numerically linear differential equations in various fields of science and engineering. The analysis was made in applied physical sciences. Some methods are applied to find the numerical solution of problems related to science and engineering. Now a day's numerical methods have been attracted the great interest towards researchers of physical and mathematical sciences and many research papers were published in these fields.

2. Undamped force of vibrations
(Forced undamped vibration is described as the kind of vibration in which a particular system encounters an outside force that makes the system vibrate). Examples of undamped forced vibration are: Movement of laundry machine due to asymmetry. The vibration of a moving transport due to its engine. Movements of strings in guitar.
Consider the undamped forced vibrations of spring given by the differential equation is

$$m\frac{d^2x}{dt^2}+kx(t)=f(t) \qquad \dots (1)$$

In this paper we take the special choice of $f(t)=(1-\sin t)$, m=1kg, k=1N/m, with initial conditions $x(0)=x'(0)=0$ then equation (1) gives us

$$\frac{d^2x}{dt^2}+x(t)=(1-\sin t),$$

As the initial conditions,
The exact solution of equation (1) by using the classical method is

$$x(t)=\frac{t^2}{2}+\sin t-\frac{xt^2}{2}+\frac{t}{2}$$

Applying initial conditions we get $C_1=-1$, $C_2=0$.

3. Runge-Kutta Method
To compute for $y(x_0+h)$ the required value of $y'(x_0+h)=z(x_0+h)$.

Firstly we compute the values of

$k_1 = hf(x_0, y_0, z_0)$; $l_1 = hg(x_0, y_0, z_0)$

$k_2 = hf\left(x_0 + h/2, y_0 + k_1/2, z_0 + l_1/2\right)$; $l_2 = hg\left(x_0 + h/2, y_0 + k_1/2, z_0 + l_1/2\right)$

$k_3 = hf\left(x_0 + h/2, y_0 + k_2/2, z_0 + l_2/2\right)$; $l_3 = hg\left(x_0 + h/2, y_0 + k_2/2, z_0 + l_2/2\right)$

$k_4 = hf\left(x_0 + h, y_0 + k_3, z_0 + l_3\right)$: $l_4 = hg(x_0 + h, y_0 + k_3, z_0 + l_3)$

$y(x_0 + h) = y_0 + 1/6\left(k_1 + 2k_2 + 2k_3 + k_4\right)$ and

$y'(x_0 + h) = z(x_0 + h) = z_0 + 1/6(l_1 + 2l_2 + 2l_3 + l_4)$

4. Eulers Modifeid Method of 2nd order

If h is the step size, Lets consider equation differential equation of (1)

$$x'' = (1 - \sin t) - x(t) \quad \ldots (2)$$

$\dfrac{dx}{dt} = z = f(t, z, x)$ then equation (1) reduces to

$$\frac{dz}{dt} = (1 - \sin(t)) - x = g(t, z, x)$$

Consider the Eulers approximation values as follows

$x_1 = x_0 + hf\left(t_0, z_0, x_0\right)$

$z_1 = z_0 + hg(t_0, z_0, x_0)$ and so on.................

Table 1: Results from Different numerical methods

h=1/32	Exact solution	Ruge Kutta Method x		Eulers Method	
t		t	Error	t	Error
1	1.2835	1.30891	0.42758	1.3005	0.43128
3	1.2568	1.74521	0.52969	1.72412	0.52712
5	2.0012	2.18151	0.53833	2.1717	0.52181
7	3.1258	3.05411	0.43125	3.0521	0.42181
9	2.8592	3.49041	0.47056	3.50125	0.42158
11	3.2561	4.36301	1.06535	4.32156	1.06421
13	3.1258	4.79932	1.6196	4.80012	1.62131
15	4.1258	5.23562	2.24149	5.28523	2.25863

5. Comparison of two numerical solutions

In this section, we compare the results of present method with classical method.

In order to verify these techniques of two methods and classical methods have been selected for our results. For both the methods we taken step size as h=1/32 has been chosen and table 1 gives a data with respect to different solutions.

6. Conclusion

Here we have assumed and taken the equation of undamped forces of vibrations which are physically represented in the form of differential equation and hence solved classical method and also numerical method and discussed.

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