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SOLUTION WITH SCIENTIFIC PACKAGING SCILAB

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SUMMARY

In the present case, the solution of the ordinary differential equation in the Scilab software package is shown.

Key words: Differential equation, Scilab package.

It is known that,

$$H(t, x, x', x'', \dots, x^{(n)}) = 0 \quad (1)$$

the equation in the form is called the n-order differential equation.

The solution of the differential equation $x(t)$, converts the equation into the same. System of n-order differential equations

$$\begin{aligned} x'_1 &= f_1(t, x_1, x_2, \dots, x_n) \\ x'_2 &= f_2(t, x_1, x_2, \dots, x_n) \\ &\vdots \\ x'_n &= f_n(t, x_1, x_2, \dots, x_n) \end{aligned} \quad (2)$$

system. (2) system solution

$$x(t) = (x_1(t), x_2(t), \dots, x_n(t))$$

It is a vector and converts the system's equations into one.

$$[y, w, iw] = ode([type], y0, t0, t, [rtol, atol], f, [jac], [w, iw])$$

Here $y0$ – initial condition vector; $t0$ - the starting point of the integration interval; t – coordinates of the network nodes; f – (2) an external function that determines the right side of the equation ; y – (3) solutions vector.

Thus,

$$\begin{aligned} \frac{dy}{dt} &= f(t, y) \\ y(t0) &= y0 \end{aligned}$$

to solve the ordinary differential equation in the form

$$y = ode(y0, t0, t, f)$$

need to call the function. **ode** Let's take a look at the non-essential parameters of the function.

type - the parameter used to select the solution method or the type of problem to be solved with one of

Differential equations and systems have an infinite number of solutions, which are constants. Additional prerequisites and boundary conditions must be provided for a single solution. The number of such conditions must be consistent with the design of the differential equation or system. Differential equations, depending on the type of additional conditions, on the Koshi problem - all additional conditions are given at one (usually the first) point of the interval. Additional terms of the boundary value problems are provided within the range boundaries.

In many cases there is an exact solution of the equations. However, sometimes it is not possible to find the exact solution of the equation, especially the system of equations. In these cases, the solution is found using numerical methods. Numerical methods are also used to find the numerical solution of the equation known as the analytical solution.

To solve the differential equation and system, Scilab has the following function.

the lines; *adams* - used in solving Adams method of differential equations or systems; *stiff*- is used for solving tough issues; *rk* - used when solving differential equations or systems; *rkf* - displayed when selecting a five-step four-way Rungee-Kutt method; *fix* - Apply the Rungee-Kutt method to the intended steps;

rtol, atol - relative and absolute errors of calculations, vector with the size y , in case of silence using $rtol = 0.00001$, $atol = 0.0000001$, *rkf* and *fix* parameters - $rtol=0.001$, $atol=0.0001$ happens; *jac* is a matrix showing the Jacobian side of the rigid system; The matrix is represented by an external function in the form of $J = jack(t, y)$; *w, iw* are vectors that store information about integration settings.

Let's look at using functions to solve the following issues.

Problem 1.

$$\frac{dx}{dt} + x = \sin(xt), x(0) = 1.5$$

let's solve the Koshi problem.

Solution

Let's write equation above the way it is

$$\frac{dx}{dt} = -x + \sin(xt), x(0) = 1.5.$$

The graphic modeling the process described in this equation is as follows:

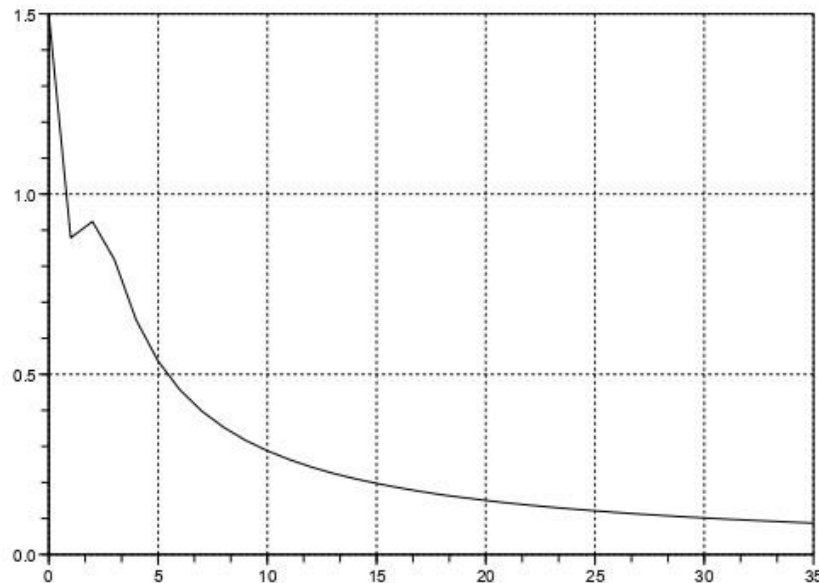


Figure 1. Problem 1's solution schedule

Then accept it as an external function

Let's use the function $y = \text{ode}(x_0, t_0, t, f)$.

Parameters we use:

f - reference to created function $f(t, x)$;

t - network coordinates;

x_0, t_0 - prerequisites $x(0) = 1.5$

y is the result of the function;

Listing 1

```
-->function      yd=f(t,x),yd=-x+sin(t*x),end
function;
```

```
-->x0=1.5;t0=0;t=0:1:35;
```

```
-->y=ode(x0,t0,t,f);
```

```
-->plot(t,y)
```

Problem 2.

$$x' = \cos(xy)$$

$$y' = \sin(x+ty)$$

$$x(0) = 0 \quad y(0) = 0$$

solve the Koshi problem in [0.10].

Below are the Siclab commands required for both numerical and graphical solution of functions and problems that describe the system of ordinary differential equations.

Listing 2

// Function describing the system of differential equations

```
function dy=syst(t,y)
```

```
dy=zeros(2,1);
```

```
dy(1)=cos(y(1)*y(2));
```

```
dy(2)=sin(y(1)+y(2)*t);
```

```
end function
```

// Solution of the system of differential equations

```
x0=[0;0];t0=0;t=0:*0.1*:10;y=ode(x0,t0,t,syst);
```

```
// Graphical solution of the problem plot(t,y)
```

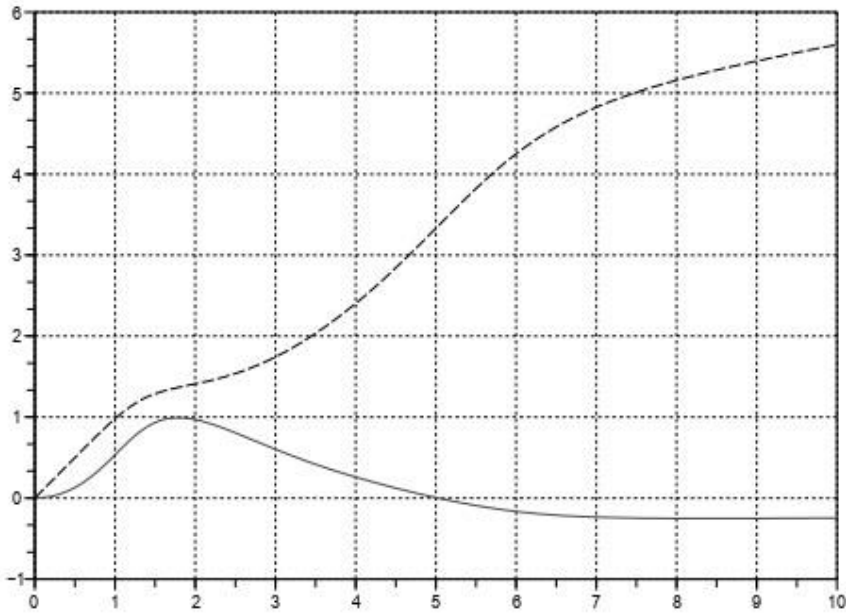


Figure 2. Problem 2's solution schedule

Problem 3. Aşağıda verilmiş sistem üçün Koşi məsələsini həll edin

$$\frac{dX}{dt} = \begin{pmatrix} 119.46 & 185.38 & 126.88 & 121.03 \\ -10.395 & -10.136 & -3.636 & 8.577 \\ -53.302 & -85.932 & -63.182 & 54.211 \\ -115.58 & -181.75 & -112.8 & -199 \end{pmatrix} X; \quad X(0) = \begin{pmatrix} 1 \\ 1 \\ 1 \\ 1 \end{pmatrix}.$$

System solution

Listing 3. Solution of Problem 3

```
-->B=[119.46 185.38 126.88 121.03;-10.395 -
10.136 -3.636 8.577;
-->-53.302 -85.932 -63.182 -54.211;-115.58 -
181.75 -112.8 -199];
-->function dx=syst1(t,x), dx=B*x, end function
```

```
-->function J=Jac(t,y),J=B, end function
```

```
-->x0=[1;1;1;1]; t0=0; t=0:0.01:5;
```

```
-->y=ode("stiff",x0,t0,t,syst1,Jac);
```

```
-->plot(t,y); xgrid();
```

Figure 3 shows the graphical solution of the problem.

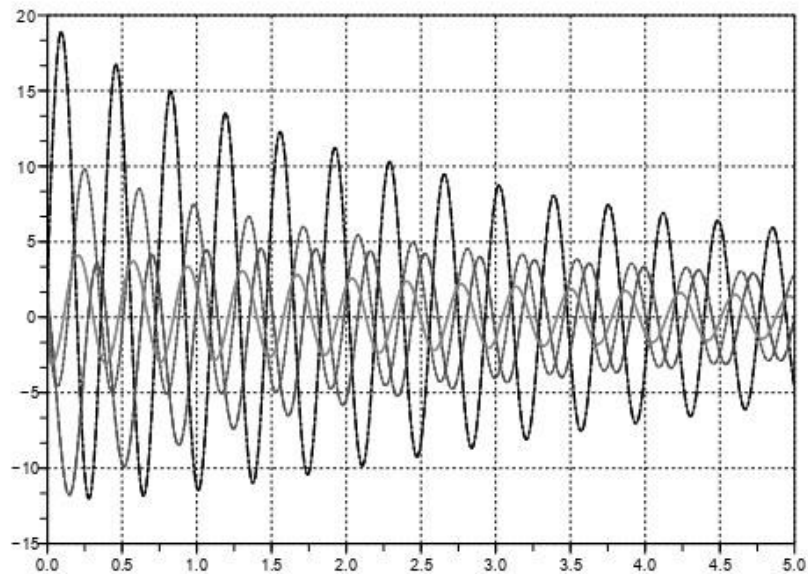


Figure 3. Problem 3 graphical solution

Problem 4. Solve the system of nonlinear rigid differential equations

$$\left\{ \begin{array}{l} \frac{dx_1}{dt} = -7x_1 + 7x_2 \\ \frac{dx_2}{dt} = 157x_1 - 1.15x_2x_3 \\ \frac{dx_3}{dt} = 0.96x_1x_2 - 8.36x_3 \end{array} \right\}, \quad X(0) = \begin{pmatrix} -1 \\ 0 \\ 1 \end{pmatrix}.$$

Figure 4 shows the solution of the system at the interval [0,2].

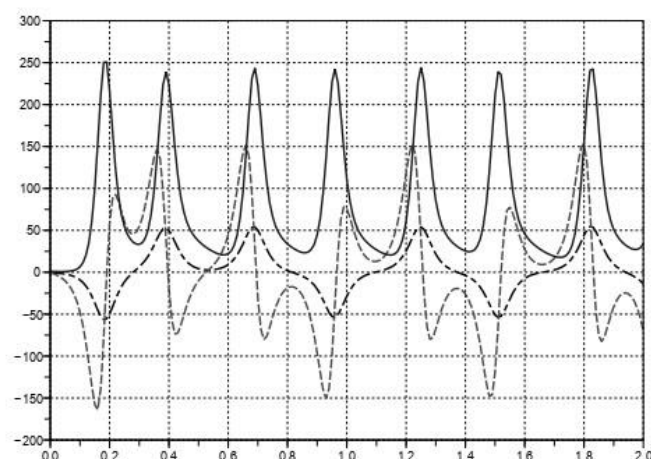


Figure 4. Problem 4 graphical solution

Listing 4.
 function dx=syst2(t,x) // Function defining a
 system of ODE
 dx=zeros(3,1);
 dx(1)=-7*x(1)+7*x(2);

dx(2)=157*x(1)+x(2)-1.15*x(1)*x(3);
 dx(3)=0.96*x(1)*x(2)-8.36*x(3);
 end function
 -->> // Solution-->x0=[-1;0;1]; t0=0;
 t=0:0.01:2;y=ode("stiff",x0,t0,t,syst2);

```
-->plot(t,y); xgrid();
```

Problem 5. Consider the following boundary problem [0.25; 2] Solve in the interval.

$$\frac{d^2x}{dt^2} + 4\frac{dx}{dt} + 13 = e^{\sin(t)}, \quad x(0.25) = -1, \quad x'(0.25) = 1.$$

Since $y = \frac{dx}{dt}$ let us convert the equation to the system by substituting it.

$$\frac{dy}{dt} = -4y - 13x + e^{\sin(t)}, \quad \frac{dx}{dt} = y, \quad y(0.25) = 1, \quad x(0.25) = -1.$$

Let us design and solve the system computing function.

Listing 5 Problem 5 solution

```
function F=FF(t,x)
F=[-4*x(1)-13*x(2)+exp(t);x(1)];
end function
-->// Solution of the system of differential
equations-->X0=[1;-1];t0=0.25;t=0.25:0.05:2;
-->y=ode("stiff",X0,t0,t,FF);
-->// Graphic representation of the solution
-->plot(t,y); xgrid();
```

The graphical solution of the problem is shown in Figure 5.

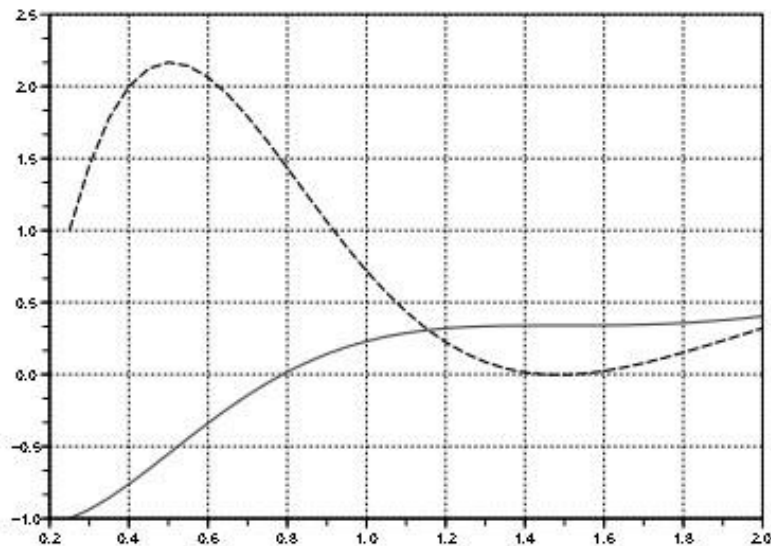


Figure 5. Problem 5's solution schedule

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