

Aplikační příklad 1.6

Ukázka pravé strany diferenciálních rovnic a variačních rovnic (pro parametr $\alpha=0.8$)

```
function dy = ap6_var1(x,y)

dy = zeros(size(y));

alpha = 0.8;

dy(1) = y(2);
dy(2) = alpha * sinh(alpha * y(1));
dy(3) = y(4);
dy(4) = alpha^2 * cosh(alpha * y(1)) * y(3);

end
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% y' = alpha * sinh(alpha * y),
% y(0)=0, y(1)=1

a = 0;
b = 1;

alpha1 = 1;
alpha2 = 1;
beta1 = 0;
beta2 = 0;
gamma1 = 0;
gamma2 = 1;

eps = 1e-8;
maxiter = 10;
Lx = linspace(a,b,40);

fprintf('-----\n');
fprintf('volba parametru: alpha = 0.8\n');

eta_0 = 1.0;
[y, eta] = MetodaStrelby(@ap6_var1,a,b,alpha1,alpha2,beta1,beta2,gamma1,gamma2,eta_0,eps,maxiter,
Lx);

if (~isempty(y))
    figure
    plot (Lx, y(:,1), 'DisplayName', 'alpha = 0.8');
    hold on;
end

fprintf('-----\n');
fprintf('volba parametru: alpha = 1\n');

eta_0 = 1.0;
[y, eta] = MetodaStrelby(@ap6_var2,a,b,alpha1,alpha2,beta1,beta2,gamma1,gamma2,eta_0,eps,maxiter,
Lx);

if (~isempty(y))
    plot (Lx, y(:,1), 'DisplayName', 'alpha = 1');
    hold on;
end

fprintf('-----\n');
fprintf('volba parametru: alpha = 2\n');

eta_0 = 1.0;
[y, eta] = MetodaStrelby(@ap6_var3,a,b,alpha1,alpha2,beta1,beta2,gamma1,gamma2,eta_0,eps,maxiter,
Lx);

if (~isempty(y))
    plot (Lx, y(:,1), 'DisplayName', 'alpha = 2');
    hold on;
end

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fprintf('-----\n');
fprintf('volba parametru: alpha = 5\n');

eta_0 = 0.05;
[y, eta] = MetodaStrelby(@ap6_var4,a,b,alpha1,alpha2,beta1,beta2,gamma1,gamma2,eta_0,eps,maxiter,
Lx);

if (~isempty(y))
    plot (Lx, y(:,1), 'DisplayName', 'alpha = 5');
    hold on;
end

fprintf('-----\n');
fprintf('volba parametru: alpha = 10\n');

eta_0 = 0.00035;
[y, eta] = MetodaStrelby(@ap6_var5,a,b,alpha1,alpha2,beta1,beta2,gamma1,gamma2,eta_0,eps,maxiter,
Lx);

if (~isempty(y))
    plot (Lx, y(:,1), 'DisplayName', 'alpha = 10');
    hold on;
end

fprintf('-----\n');
fprintf('volba parametru: alpha = 20\n');

eta_0 = 7e-8;
[y, eta] = MetodaStrelby(@ap6_var6,a,b,alpha1,alpha2,beta1,beta2,gamma1,gamma2,eta_0,eps,maxiter,
Lx);

if (~isempty(y))
    plot (Lx, y(:,1), 'DisplayName', 'alpha = 20');
end

xlabel('x');
ylabel('y(x)');
title('Sloupec plazmy stlacovane zarenim');
legend('show','Location','northwest');

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volba parametru: alpha = 0.8
k = 0, eta = 1.000000000e+00
k = 1, eta = 8.98230638e-01, delta = 1.01769362e-01
k = 2, eta = 8.98115230e-01, delta = 1.15407832e-04
k = 3, eta = 8.98115230e-01, delta = 1.36754608e-10
Reseni:

```

x	y1(x)	y2(x)
0.000,	0.000000,	0.898115
0.026,	0.023030,	0.898304
0.051,	0.046070,	0.898871
0.077,	0.069129,	0.899817
0.103,	0.092218,	0.901142
0.128,	0.115345,	0.902847

0.154,	0.138521,	0.904933
0.179,	0.161755,	0.907403
0.205,	0.185058,	0.910257
0.231,	0.208438,	0.913499
0.256,	0.231907,	0.917131
0.282,	0.255474,	0.921155
0.308,	0.279149,	0.925576
0.333,	0.302943,	0.930395
0.359,	0.326865,	0.935617
0.385,	0.350927,	0.941247
0.410,	0.375138,	0.947288
0.436,	0.399509,	0.953746
0.462,	0.424052,	0.960627
0.487,	0.448776,	0.967935
0.513,	0.473693,	0.975676
0.538,	0.498814,	0.983858
0.564,	0.524151,	0.992488
0.590,	0.549715,	1.001572
0.615,	0.575518,	1.011120
0.641,	0.601571,	1.021139
0.667,	0.627888,	1.031638
0.692,	0.654480,	1.042627
0.718,	0.681360,	1.054117
0.744,	0.708542,	1.066117
0.769,	0.736037,	1.078641
0.795,	0.763861,	1.091699
0.821,	0.792027,	1.105305
0.846,	0.820548,	1.119473
0.872,	0.849440,	1.134217
0.897,	0.878718,	1.149553
0.923,	0.908397,	1.165498
0.949,	0.938493,	1.182068
0.974,	0.969021,	1.199282
1.000,	1.000000,	1.217161

volba parametru: alpha = 1

k = 0,	eta =	1.000000000e+00	
k = 1,	eta =	8.45887643e-01,	delta = 1.54112357e-01
k = 2,	eta =	8.45202696e-01,	delta = 6.84947740e-04
k = 3,	eta =	8.45202684e-01,	delta = 1.17699613e-08
k = 4,	eta =	8.45202684e-01,	delta = 3.33066907e-16

Reseni:

x	y1(x)	y2(x)
0.000,	0.000000,	0.845203
0.026,	0.021674,	0.845481
0.051,	0.043363,	0.846314
0.077,	0.065080,	0.847705
0.103,	0.086840,	0.849655
0.128,	0.108657,	0.852165
0.154,	0.130545,	0.855239
0.179,	0.152520,	0.858880
0.205,	0.174595,	0.863092
0.231,	0.196786,	0.867881
0.256,	0.219107,	0.873251
0.282,	0.241573,	0.879210
0.308,	0.264200,	0.885763

0.333,	0.287002,	0.892919
0.359,	0.309996,	0.900687
0.385,	0.333196,	0.909076
0.410,	0.356620,	0.918095
0.436,	0.380284,	0.927758
0.462,	0.404203,	0.938075
0.487,	0.428396,	0.949060
0.513,	0.452879,	0.960727
0.538,	0.477670,	0.973092
0.564,	0.502787,	0.986171
0.590,	0.528249,	0.999982
0.615,	0.554075,	1.014545
0.641,	0.580283,	1.029880
0.667,	0.606896,	1.046009
0.692,	0.633932,	1.062957
0.718,	0.661413,	1.080749
0.744,	0.689362,	1.099413
0.769,	0.717801,	1.118978
0.795,	0.746754,	1.139478
0.821,	0.776244,	1.160945
0.846,	0.806298,	1.183418
0.872,	0.836941,	1.206936
0.897,	0.868201,	1.231542
0.923,	0.900107,	1.257283
0.949,	0.932688,	1.284209
0.974,	0.965974,	1.312374
1.000,	1.000000,	1.341838

volba parametru: $\alpha = 2$

k = 0,	eta =	1.000000000e+00	
k = 1,	eta =	7.28747803e-01,	delta = 2.71252197e-01
k = 2,	eta =	5.44199875e-01,	delta = 1.84547928e-01
k = 3,	eta =	5.18902259e-01,	delta = 2.52976161e-02
k = 4,	eta =	5.18621257e-01,	delta = 2.81002205e-04
k = 5,	eta =	5.18621225e-01,	delta = 3.25111996e-08
k = 6,	eta =	5.18621225e-01,	delta = 5.55111512e-16

Reseni:

x	y1(x)	y2(x)
0.000,	0.000000,	0.518621
0.026,	0.013304,	0.519303
0.051,	0.026643,	0.521352
0.077,	0.040052,	0.524774
0.103,	0.053566,	0.529581
0.128,	0.067222,	0.535789
0.154,	0.081055,	0.543420
0.179,	0.095102,	0.552498
0.205,	0.109400,	0.563057
0.231,	0.123989,	0.575132
0.256,	0.138908,	0.588767
0.282,	0.154196,	0.604012
0.308,	0.169897,	0.620921
0.333,	0.186053,	0.639559
0.359,	0.202710,	0.659998
0.385,	0.219915,	0.682318
0.410,	0.237718,	0.706609

0.436,	0.256169,	0.732974
0.462,	0.275325,	0.761527
0.487,	0.295242,	0.792394
0.513,	0.315981,	0.825721
0.538,	0.337609,	0.861669
0.564,	0.360194,	0.900423
0.590,	0.383810,	0.942187
0.615,	0.408539,	0.987199
0.641,	0.434466,	1.035726
0.667,	0.461686,	1.088077
0.692,	0.490300,	1.144600
0.718,	0.520422,	1.205707
0.744,	0.552175,	1.271871
0.769,	0.585694,	1.343643
0.795,	0.621133,	1.421669
0.821,	0.658660,	1.506725
0.846,	0.698469,	1.599728
0.872,	0.740776,	1.701770
0.897,	0.785827,	1.814182
0.923,	0.833912,	1.938618
0.949,	0.885364,	2.077091
0.974,	0.940571,	2.232122
1.000,	1.000000,	2.406939

volba parametru: alpha = 5

k = 0,	eta =	5.000000000e-02	
k = 1,	eta =	4.70629630e-02,	delta = 2.93703704e-03
k = 2,	eta =	4.58543174e-02,	delta = 1.20864555e-03
k = 3,	eta =	4.57515172e-02,	delta = 1.02800232e-04
k = 4,	eta =	4.57509266e-02,	delta = 5.90608907e-07
k = 5,	eta =	4.57509266e-02,	delta = 4.73669992e-11

Reseni:

x	y1(x)	y2(x)
0.000,	0.000000,	0.045751
0.026,	0.001176,	0.046127
0.051,	0.002372,	0.047263
0.077,	0.003607,	0.049177
0.103,	0.004901,	0.051900
0.128,	0.006276,	0.055478
0.154,	0.007754,	0.059970
0.179,	0.009359,	0.065449
0.205,	0.011119,	0.072006
0.231,	0.013062,	0.079751
0.256,	0.015220,	0.088811
0.282,	0.017629,	0.099337
0.308,	0.020328,	0.111504
0.333,	0.023363,	0.125517
0.359,	0.026783,	0.141610
0.385,	0.030645,	0.160055
0.410,	0.035014,	0.181164
0.436,	0.039961,	0.205303
0.462,	0.045572,	0.232891
0.487,	0.051938,	0.264410
0.513,	0.059169,	0.300431
0.538,	0.067389,	0.341620
0.564,	0.076740,	0.388761

0.590,	0.087385,	0.442774
0.615,	0.099514,	0.504793
0.641,	0.113352,	0.576196
0.667,	0.129160,	0.658673
0.692,	0.147242,	0.754320
0.718,	0.167976,	0.865982
0.744,	0.191825,	0.997385
0.769,	0.219350,	1.153442
0.795,	0.251241,	1.341039
0.821,	0.288468,	1.571245
0.846,	0.332323,	1.860101
0.872,	0.384577,	2.233365
0.897,	0.447964,	2.738653
0.923,	0.526886,	3.465113
0.949,	0.629210,	4.614192
0.974,	0.771491,	6.735830
1.000,	1.000000,	12.100529

volba parametru: alpha = 10

k = 0,	eta =	3.500000000e-04	
k = 1,	eta =	3.63044630e-04,	delta = 1.30446300e-05
k = 2,	eta =	3.62578640e-04,	delta = 4.65989594e-07
k = 3,	eta =	3.61327208e-04,	delta = 1.25143213e-06
k = 4,	eta =	3.59535949e-04,	delta = 1.79125922e-06
k = 5,	eta =	3.58478991e-04,	delta = 1.05695795e-06
k = 6,	eta =	3.58313800e-04,	delta = 1.65191528e-07
k = 7,	eta =	3.58310906e-04,	delta = 2.89398311e-09

Reseni:

x	y1(x)	y2(x)
0.000,	0.000000,	0.000358
0.026,	0.000009,	0.000370
0.051,	0.000019,	0.000406
0.077,	0.000030,	0.000470
0.103,	0.000044,	0.000564
0.128,	0.000060,	0.000695
0.154,	0.000080,	0.000873
0.179,	0.000105,	0.001108
0.205,	0.000137,	0.001417
0.231,	0.000178,	0.001819
0.256,	0.000231,	0.002341
0.282,	0.000300,	0.003018
0.308,	0.000388,	0.003895
0.333,	0.000502,	0.005029
0.359,	0.000649,	0.006495
0.385,	0.000838,	0.008391
0.410,	0.001084,	0.010843
0.436,	0.001400,	0.014010
0.462,	0.001810,	0.018102
0.487,	0.002339,	0.023394
0.513,	0.003023,	0.030235
0.538,	0.003907,	0.039069
0.564,	0.005048,	0.050489
0.590,	0.006524,	0.065257
0.615,	0.008433,	0.084354
0.641,	0.010897,	0.109027

0.667,	0.014084,	0.140960
0.692,	0.018208,	0.182332
0.718,	0.023544,	0.235982
0.744,	0.030444,	0.305577
0.769,	0.039391,	0.396433
0.795,	0.051020,	0.515766
0.821,	0.066175,	0.673811
0.846,	0.086039,	0.887112
0.872,	0.112378,	1.183853
0.897,	0.147899,	1.617419
0.923,	0.197494,	2.311685
0.949,	0.271555,	3.629946
0.974,	0.401798,	7.321819
1.000,	1.000000,	148.407752

volba parametru: alpha = 20

k = 0, eta = 7.00000000e-08

Warning: Failure at t=9.277077e-01. Unable to meet integration tolerances without reducing the step size below the smallest value allowed (1.776357e-15) at time t.

k = 1, eta = 1.14972992e-07, delta = 4.49729924e-08

Warning: Failure at t=9.028992e-01. Unable to meet integration tolerances without reducing the step size below the smallest value allowed (1.776357e-15) at time t.

k = 2, eta = 2.04250133e-07, delta = 8.92771406e-08

Warning: Failure at t=8.741653e-01. Unable to meet integration tolerances without reducing the step size below the smallest value allowed (1.776357e-15) at time t.

k = 3, eta = 2.64878074e-07, delta = 6.06279409e-08

Warning: Failure at t=8.611697e-01. Unable to meet integration tolerances without reducing the step size below the smallest value allowed (1.776357e-15) at time t.

k = 4, eta = 9.18752027e-07, delta = 6.53873953e-07

Warning: Failure at t=7.989829e-01. Unable to meet integration tolerances without reducing the step size below the smallest value allowed (1.776357e-15) at time t.

k = 5, eta = 1.43364055e-06, delta = 5.14888519e-07

Warning: Failure at t=7.767371e-01. Unable to meet integration tolerances without reducing the step size below the smallest value allowed (1.776357e-15) at time t.

k = 6, eta = 3.03434356e-06, delta = 1.60070301e-06

Warning: Failure at t=7.392465e-01. Unable to meet integration tolerances without reducing the step size below the smallest value allowed (1.776357e-15) at time t.

k = 7, eta = 1.42757084e-05, delta = 1.12413649e-05

Warning: Failure at t=6.618203e-01. Unable to meet integration tolerances without reducing the step size below the smallest value allowed (1.776357e-15) at time t.

k = 8, eta = 6.57041272e-05, delta = 5.14284188e-05

Warning: Failure at t=5.854881e-01. Unable to meet integration tolerances without reducing the step size below the smallest value allowed (1.776357e-15) at time t.

k = 9, eta = 3.10269397e-04, delta = 2.44565270e-04

Warning: Failure at t=5.078753e-01. Unable to meet integration tolerances without reducing the step size below the smallest value allowed (1.776357e-15) at time t.

k = 10, eta = 1.42155287e-03, delta = 1.11128347e-03

Warning: Failure at t=4.317738e-01. Unable to meet integration tolerances without reducing the step size below the smallest value allowed (8.881784e-16) at time t.

k = 11, eta = 6.75223865e-03, delta = 5.33068578e-03

Metoda nekonverguje. Vycerpan maximalni pocet iteraci Newtonovy metody

