№3

2025-03-22

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. ,
xt() yt(). 25 000 ,
39 000 . , a, b, c, h .
Pt() Qt() .

1. $\frac{dx}{dt} = -0.411*x(t)-0.733*y(t)+sin(2*t)+1$ $\frac{dy}{dt} = -0.55*x(t) - 0.664*y(t) + cos(2*t) + 1$
2. $\frac{dx}{dt} = -0.399*x(t)y(t) - 0.688*y(t) + sin(2*t) + 2$ $\frac{dy}{dt} = -0.299*x(t) - 0.811*y(t) + cos(3*t) + 1$

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: (1132226460%70)+1 = 51 .

$\frac{dx}{dt} = -0.411 * x(t) - 0.733 * y(t) + sin(2 * t) + 1$ $\frac{dy}{dt} = -0.55 * x(t) - 0.664 * y(t) + cos(2 * t) + 1$

, , -0.411x(t) -0.664y(t) (x y -
,), - 0.733y(t) -0.55x(t)
(x y).
P(t) = sin(2t)+1, Q(t) = cos(2t)+ 1
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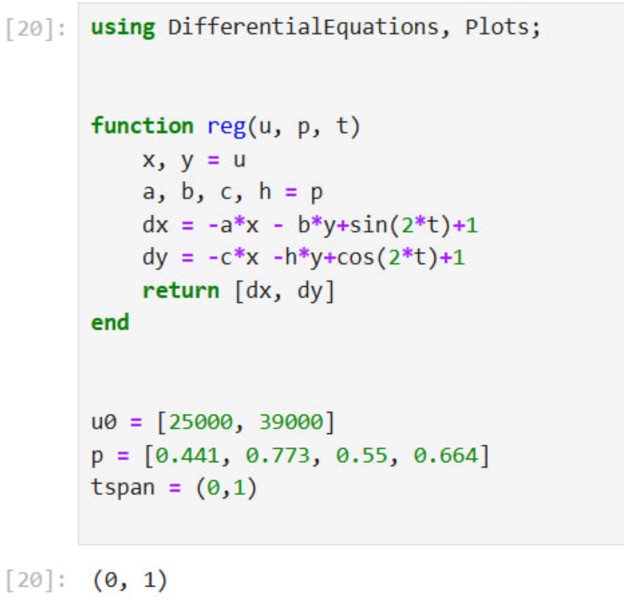
Julia:

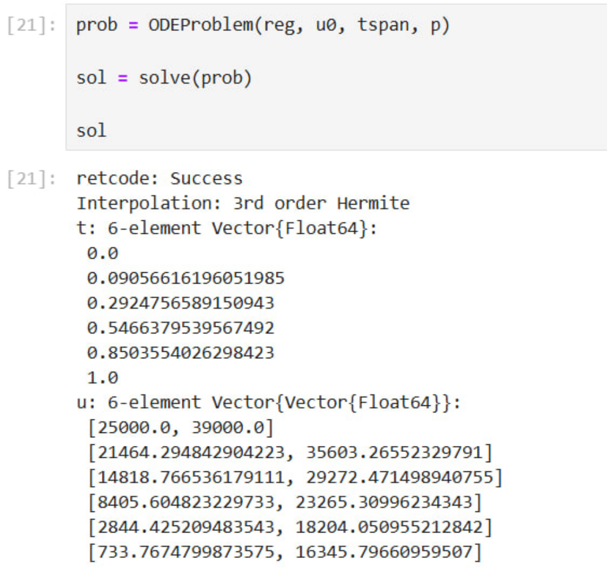


```
[20]: using DifferentialEquations, Plots;


      function reg(u, p, t)
          x, y = u
          a, b, c, h = p
          dx = -a*x - b*y+sin(2*t)+1
          dy = -c*x -h*y+cos(2*t)+1
          return [dx, dy]
      end


      u0 = [25000, 39000]
      p = [0.441, 0.773, 0.55, 0.664]
      tspan = (0,1)

[20]: (0, 1)
```

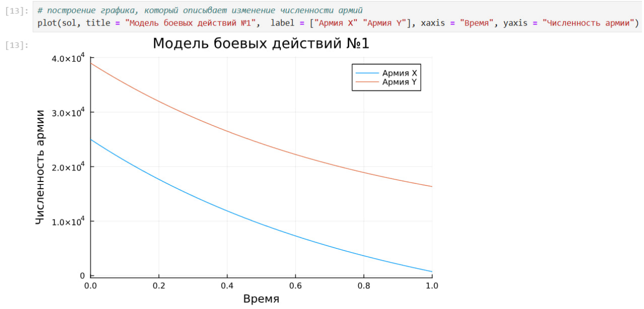


```
[21]: prob = ODEProblem(reg, u0, tspan, p)

      sol = solve(prob)

      sol
```

```
[21]: retcode: Success
      Interpolation: 3rd order Hermite
      t: 6-element Vector{Float64}:
       0.0
       0.09056616196051985
       0.2924756589150943
       0.5466379539567492
       0.8503554026298423
       1.0
      u: 6-element Vector{Vector{Float64}}:
       [25000.0, 39000.0]
       [21464.294842904223, 35603.26552329791]
       [14818.766536179111, 29272.471498940755]
       [8405.604823229733, 23265.30996234343]
       [2844.425209483543, 18204.050955212842]
       [733.7674799873575, 16345.79660959507]
```



```
[13]: # построение графика, который описывает изменение численности армий
      plot(sol, title = "Модель боевых действий №1",  label = ["Армия X" "Армия Y"], xaxis = "Время", yaxis = "Численность армии")
```

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OpenModelica.

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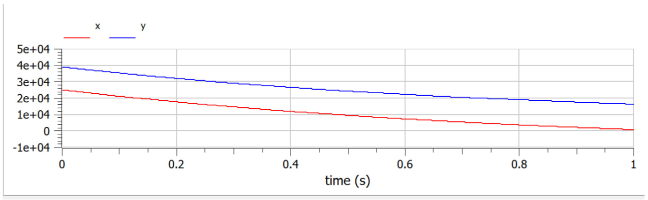
```
model lab3
  parameter Real a = 0.441;
  parameter Real b = 0.773;
  parameter Real c = 0.55;
  parameter Real h = 0.664;
  parameter Real x0 = 25000;
  parameter Real y0 = 39000;
  Real x(start=x0);
```

```
  Real y(start=y0);
equation
  der(x) = -a*x - b*y+sin(2*time)+1;
  der(y) = -c*x -h*y+cos(2*time)+1;
end lab3;
```



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$\frac{dx}{dt} = -0.399 * x(t)y(t) - 0.688 * y(t) + sin(2*t) + 2 \quad \frac{dy}{dt} = -0.299 * x(t) - 0.811 * y(t) + cos(3*t) + 1$

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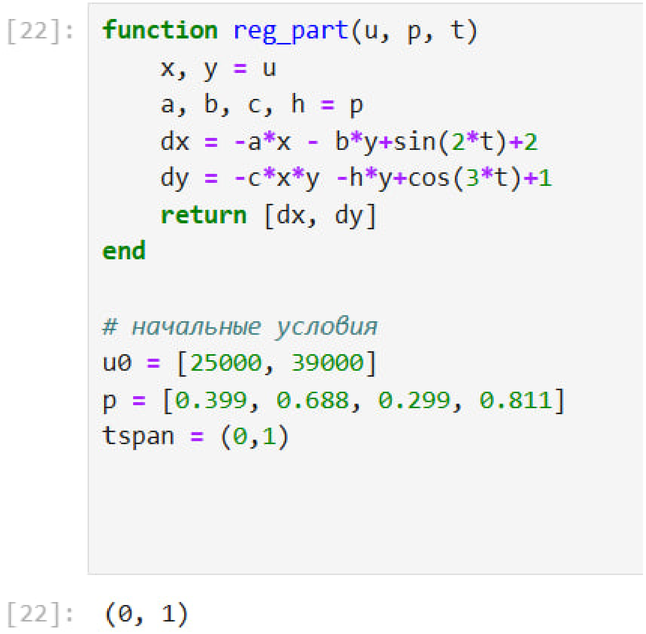
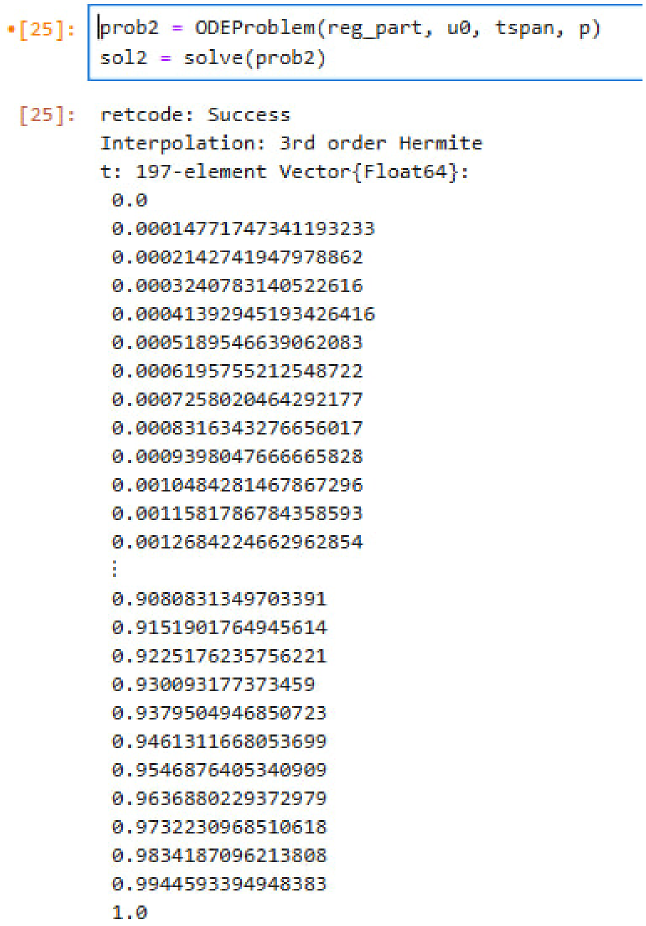
Julia:



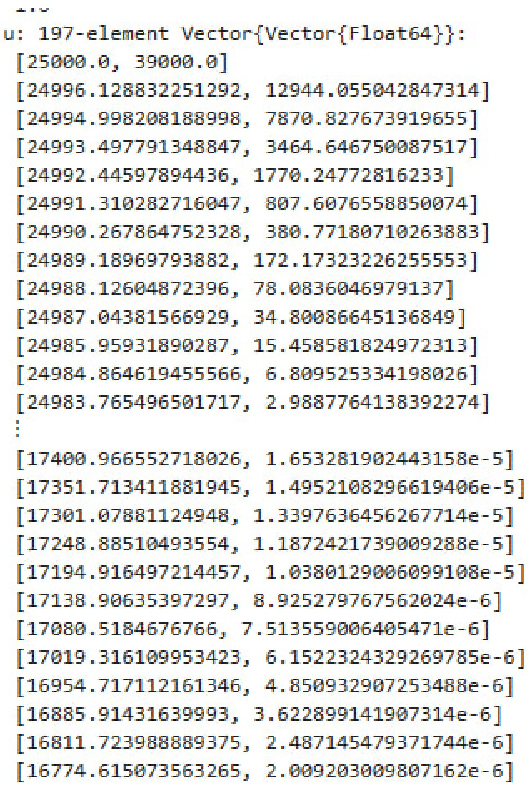
```
[22]: function reg_part(u, p, t)
          x, y = u
          a, b, c, h = p
          dx = -a*x - b*y+sin(2*t)+2
          dy = -c*x*y -h*y+cos(3*t)+1
          return [dx, dy]
      end

      # начальные условия
      u0 = [25000, 39000]
      p = [0.399, 0.688, 0.299, 0.811]
      tspan = (0,1)
```

```
[22]: (0, 1)
```

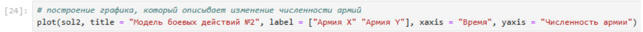


```
prob2 = ODEProblem(reg_part, u0, tspan, p)
sol2 = solve(prob2)
```

```
retcode: Success
Interpolation: 3rd order Hermite
t: 197-element Vector{Float64}:
 0.0
 0.00014771747341193233
 0.0002142741947978862
 0.0003240783140522616
 0.00041392945193426416
 0.0005189546639062083
 0.0006195755212548722
 0.0007258020464292177
 0.0008316343276656017
 0.0009398047666665828
 0.0010484281467867296
 0.0011581786784358593
 0.0012684224662962854
 ⋮
 0.9080831349703391
 0.9151901764945614
 0.9225176235756221
 0.930093177373459
 0.9379504946850723
 0.9461311668053699
 0.9546876405340909
 0.9636880229372979
 0.9732230968510618
 0.9834187096213808
 0.9944593394948383
 1.0
```

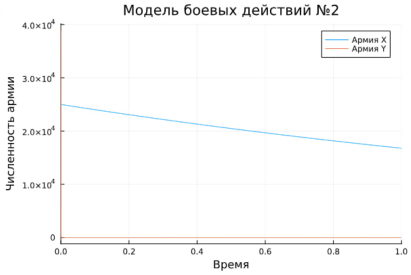


```
 1.0
u: 197-element Vector{Vector{Float64}}:
 [25000.0, 39000.0]
 [24996.128832251292, 12944.055042847314]
 [24994.998208188998, 7870.827673919655]
 [24993.497791348847, 3464.646750087517]
 [24992.44597894436, 1770.24772816233]
 [24991.310282716047, 807.6076558850074]
 [24990.267864752328, 380.77180710263883]
 [24989.18969793882, 172.17323226255553]
 [24988.12604872396, 78.0836046979137]
 [24987.04381566929, 34.80086645136849]
 [24985.95931890287, 15.458581824972313]
 [24984.864619455566, 6.809525334198026]
 [24983.765496501717, 2.9887764138392274]
 ⋮
 [17400.966552718026, 1.653281902443158e-5]
 [17351.713411881945, 1.4952108296619406e-5]
 [17301.07881124948, 1.3397636456267714e-5]
 [17248.88510493554, 1.1872421739009288e-5]
 [17194.916497214457, 1.0380129006099108e-5]
 [17138.90635397297, 8.925279767562024e-6]
 [17080.5184676766, 7.513559006405471e-6]
 [17019.316109953423, 6.1522324329269785e-6]
 [16954.717112161346, 4.850932907253488e-6]
 [16885.91431639993, 3.622899141907314e-6]
 [16811.723988889375, 2.487145479371744e-6]
 [16774.615073563265, 2.009203009807162e-6]
```



```
[24]: # построение графика, который описывает изменение численности армий
      plot(sol2, title = "Модель боевых действий №2", label = ["Армия X" "Армия Y"], xaxis = "Время", yaxis = "Численность армии")
```

[24]:



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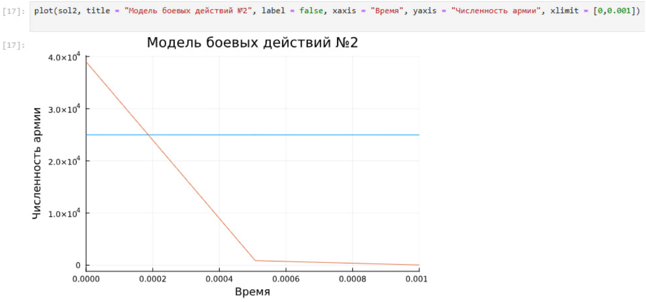

```
[17]: plot(sol2, title = "Модель боевых действий №2", label = false, xaxis = "Время", yaxis = "Численность армии", xlimit = [0,0.001])
```

X, Y .
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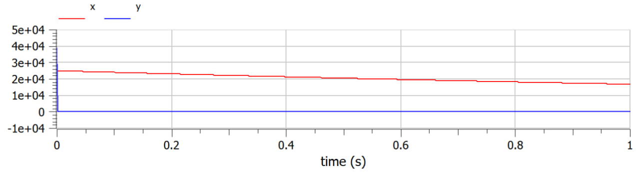
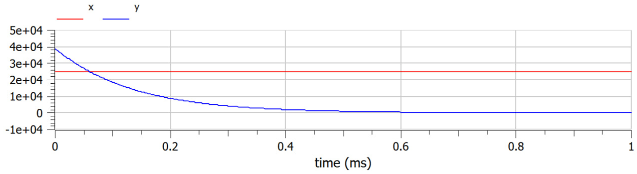
OpenModelica.

```
model lab3_part
  parameter Real a = 0.399;
  parameter Real b = 0.688;
  parameter Real c = 0.299;
  parameter Real h = 0.811;
  parameter Real x0 = 25000;
  parameter Real y0 = 39000;
  Real x(start=x0);
  Real y(start=y0);
equation
  der(x) = -a*x - b*y+sin(2*time)+2;
  der(y) = -c*x*y -h*y+cos(3*time)+1;
end lab3_part;
```



, , Y



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