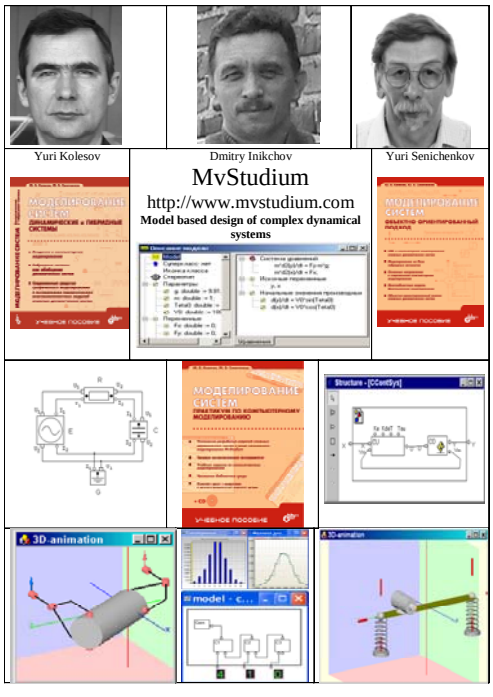
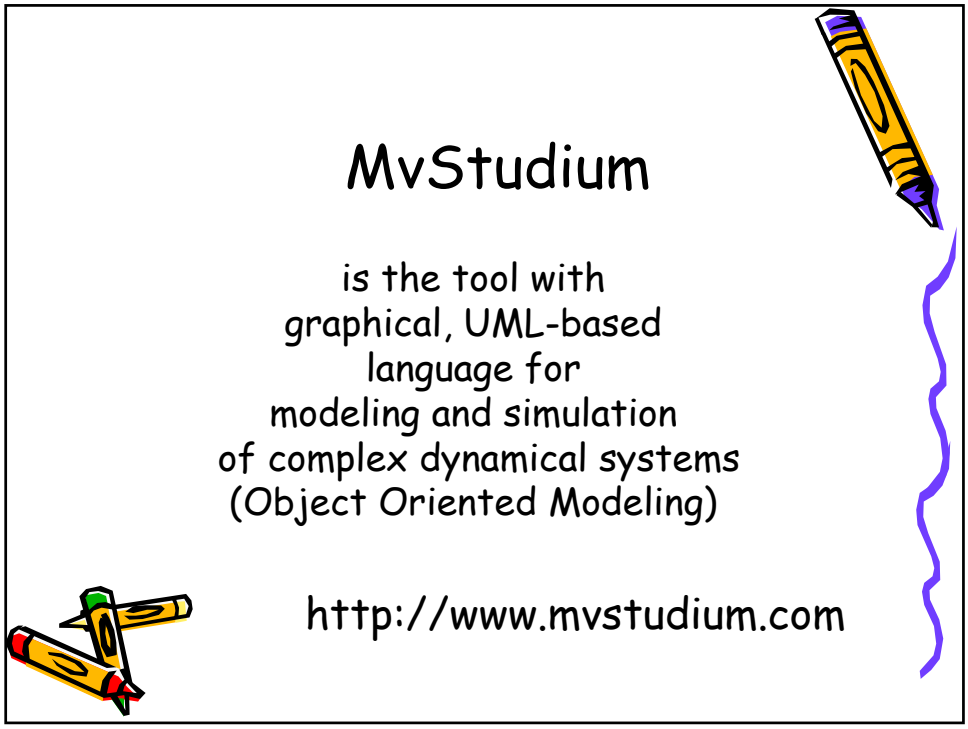
Physical Modelling with ModelVision, a DAE Simulator with Features for Hybrid Automata

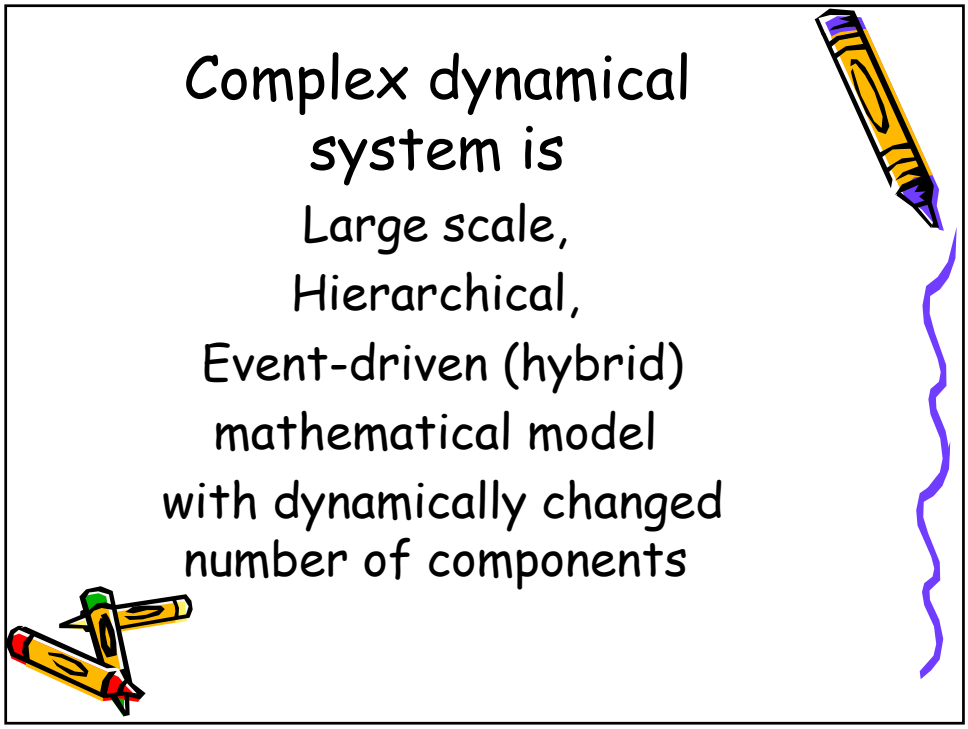
MVStudium Project

D. Inikchov, Yu. Kolesov
Yu. Senichenkov
TU St. Petersburg

F. Breitenecker
G. Zauner
TU Vienna

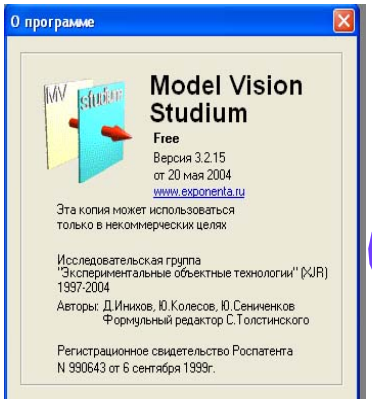


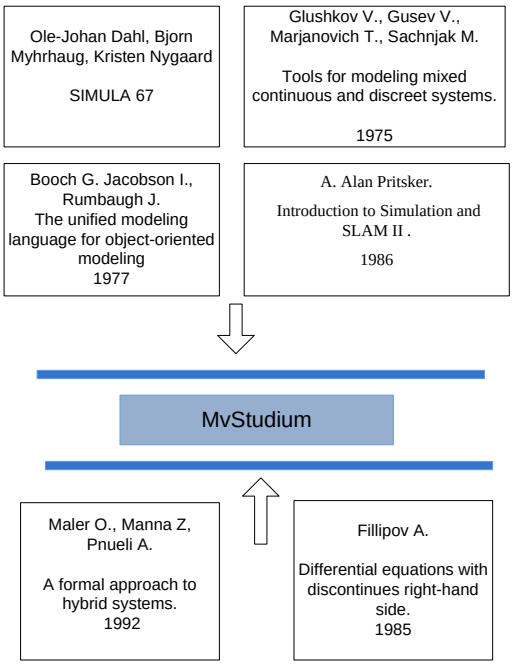

MvStudium
is the tool with
graphical, UML-based
language for
modeling and simulation
of complex dynamical systems
(Object Oriented Modeling)
http://www.mvstudium.com


Complex dynamical
system is
Large scale,
Hierarchical,
Event-driven (hybrid)
mathematical model
with dynamically changed
number of components

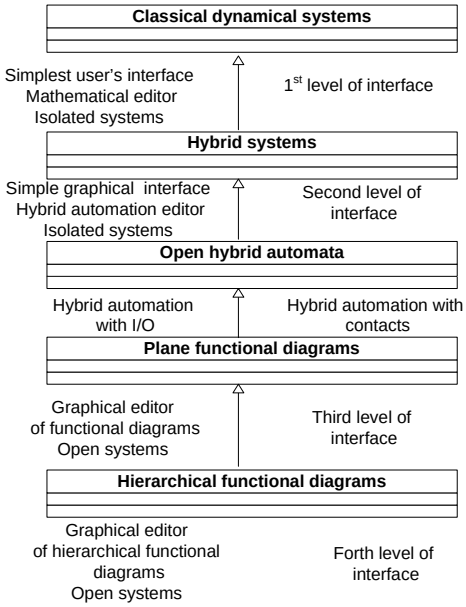
The Model Vision Family

- MV 2.1 (1994-96)
- MVS 3.0 (1996-2003)
- MVS 4.X – 2004-????

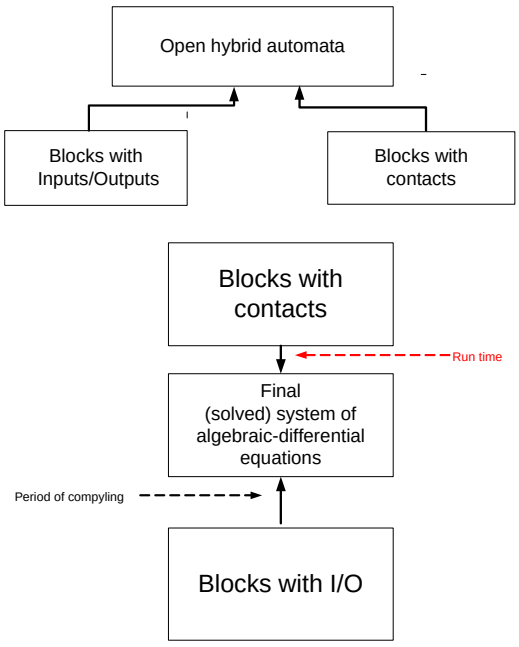


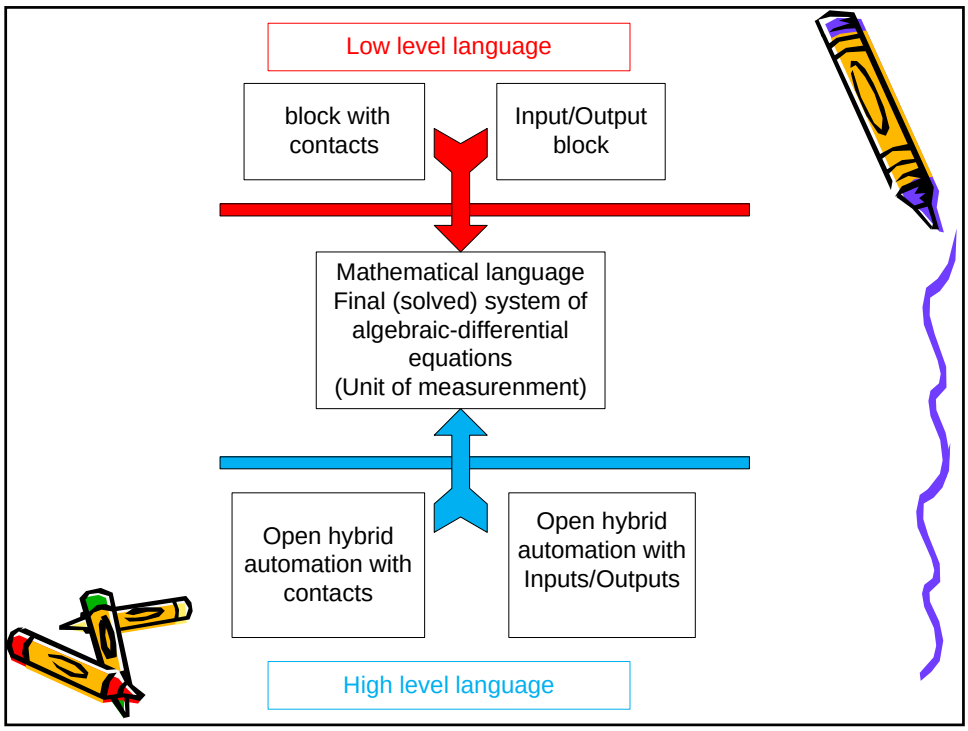


MvStudium models



Mvstudium hybrid blocks





MvStudium's simplest mathematical models

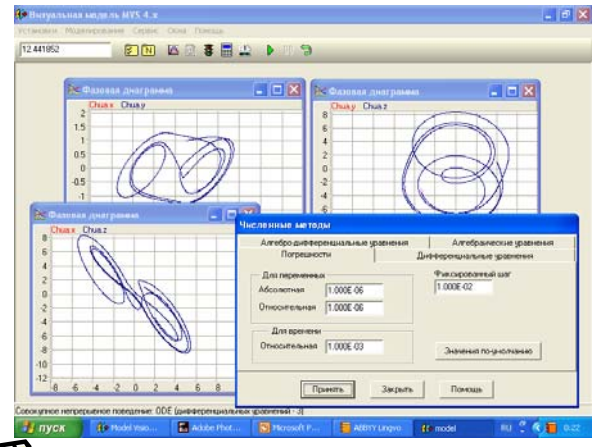
Classical dynamical system (continuous time)

is a system of differential equations

$$\frac{dx}{dt} = f(x), x \in \Re^n, x(0) = x^0$$

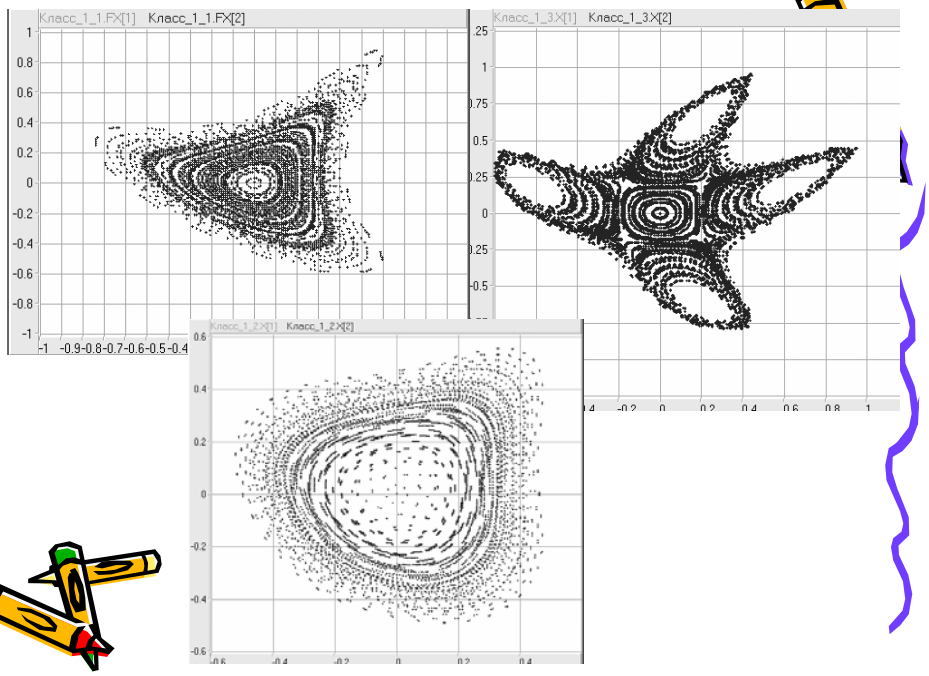
with right hand side $f(x)$, ensuring existence and uniqueness of the solution

$$x = x(t; x^0)$$

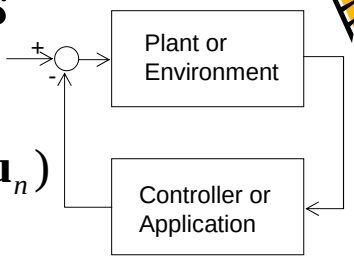


Discreet dynamical systems (discreet time). Difference equations

$$\begin{cases} x_{n+1} = x_n \cdot \cos\alpha - \left(y_n - x_n^2\right) \cdot \sin\alpha \\ y_{n+1} = x_n \cdot \sin\alpha - \left(y_n - x_n^2\right) \cdot \cos\alpha \end{cases}$$



Discrete-continuous systems



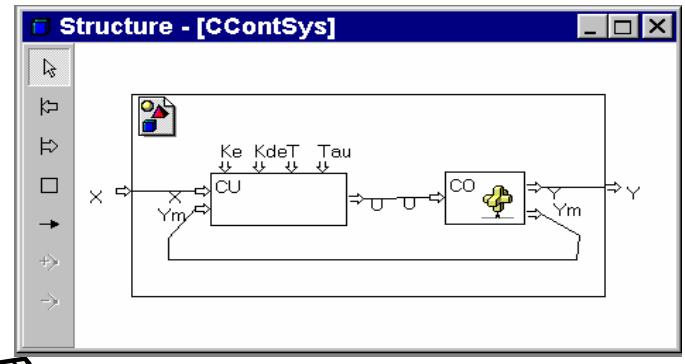
- Object of control

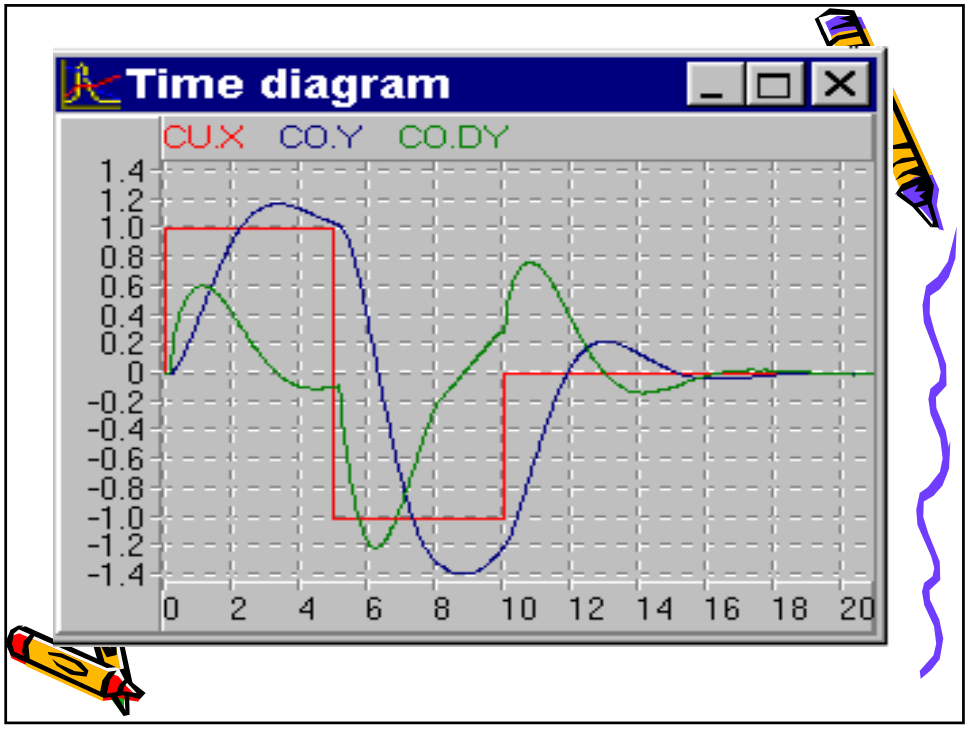
$$\frac{d\mathbf{x}}{dt} = \mathbf{f}(\mathbf{x}(t), \mathbf{u}_n)$$

- Control

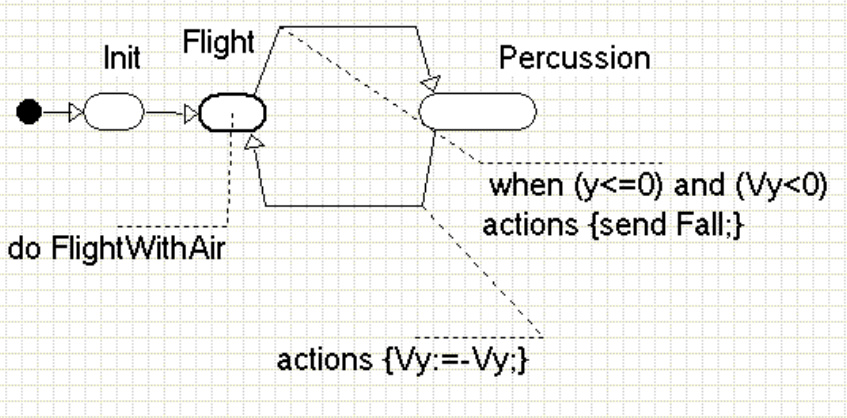
$$\mathbf{u}_{n+1} = \mathbf{G}(\mathbf{x}(t_n), \mathbf{u}_n),$$
$$\mathbf{u}_n = \mathbf{u}(t_n), t_{n+1} = t_n + h,$$

Control system

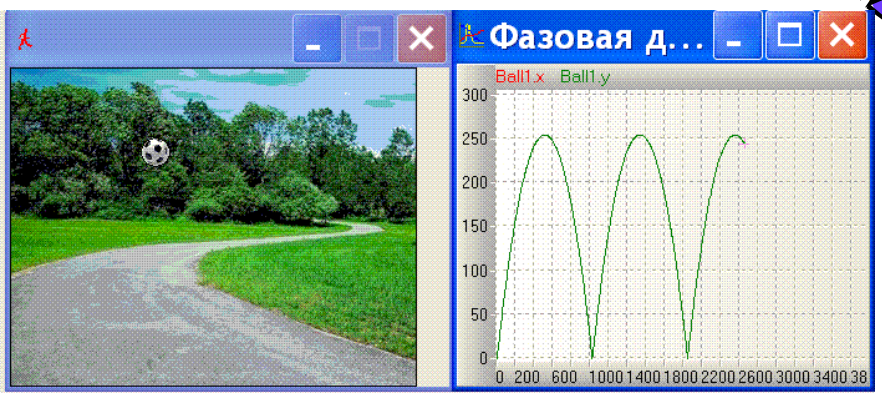




Hybrid systems

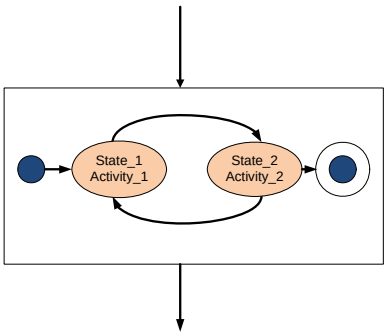


Bouncing ball

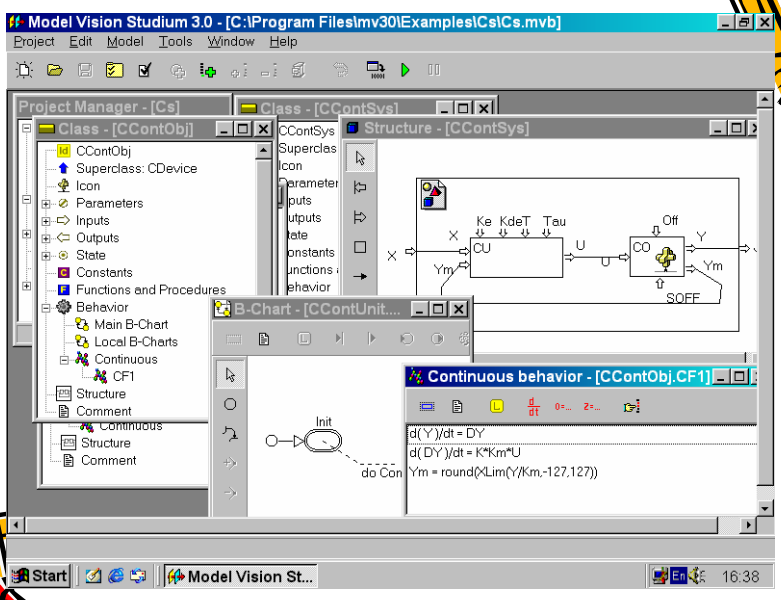


MvStudium's Blocks

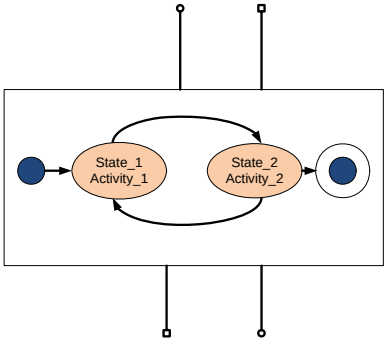
Open I/O block with hybrid automation



Activity: $F(\frac{dx}{dt}, x, t; x_0)$

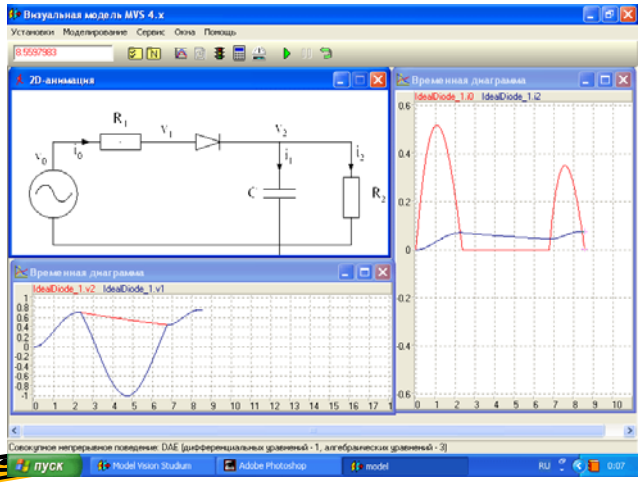


Open Contact/Flow block with hybrid automation

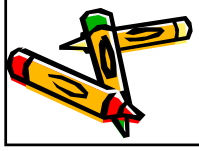


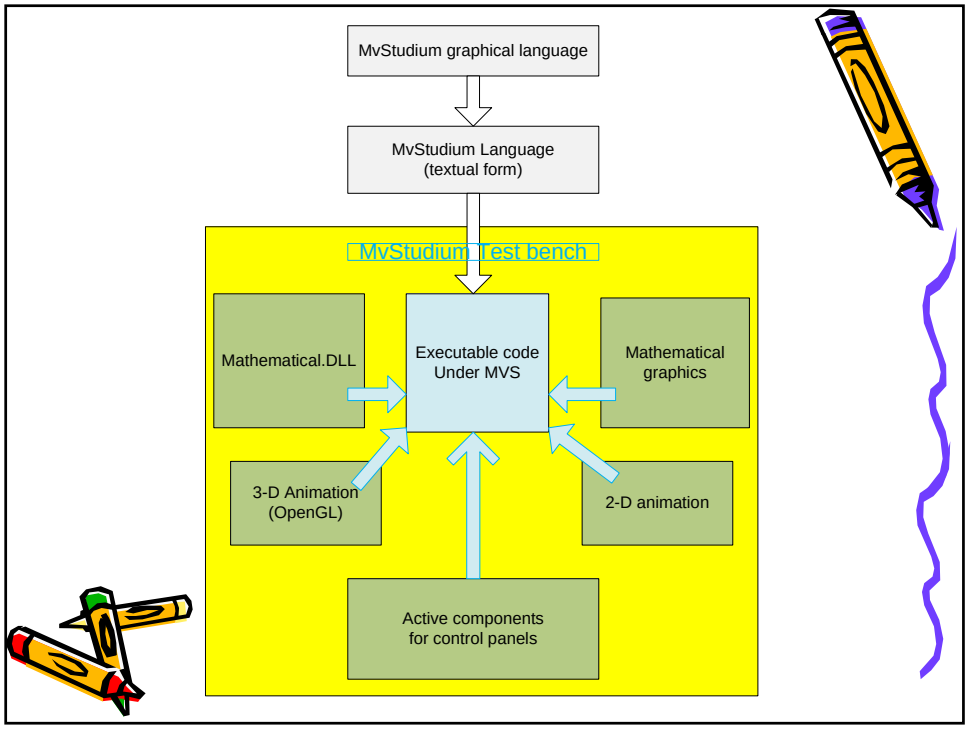
Activity: $F(\frac{dx}{dt}, x, t; x_0)$

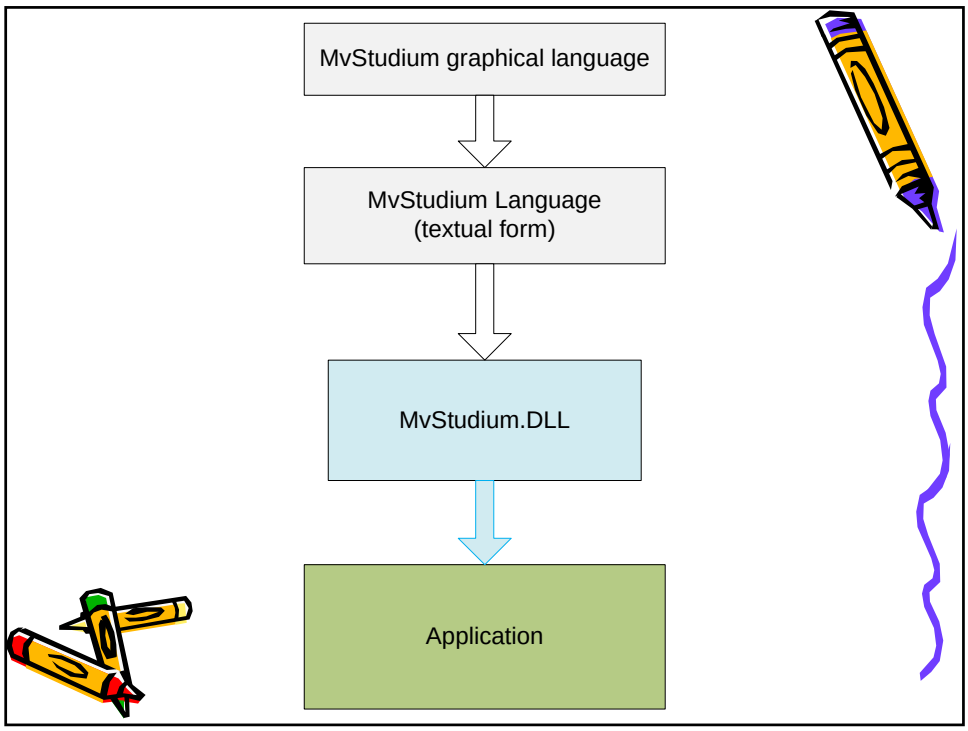
Ideal diode (test bench)



MvStudium's executives

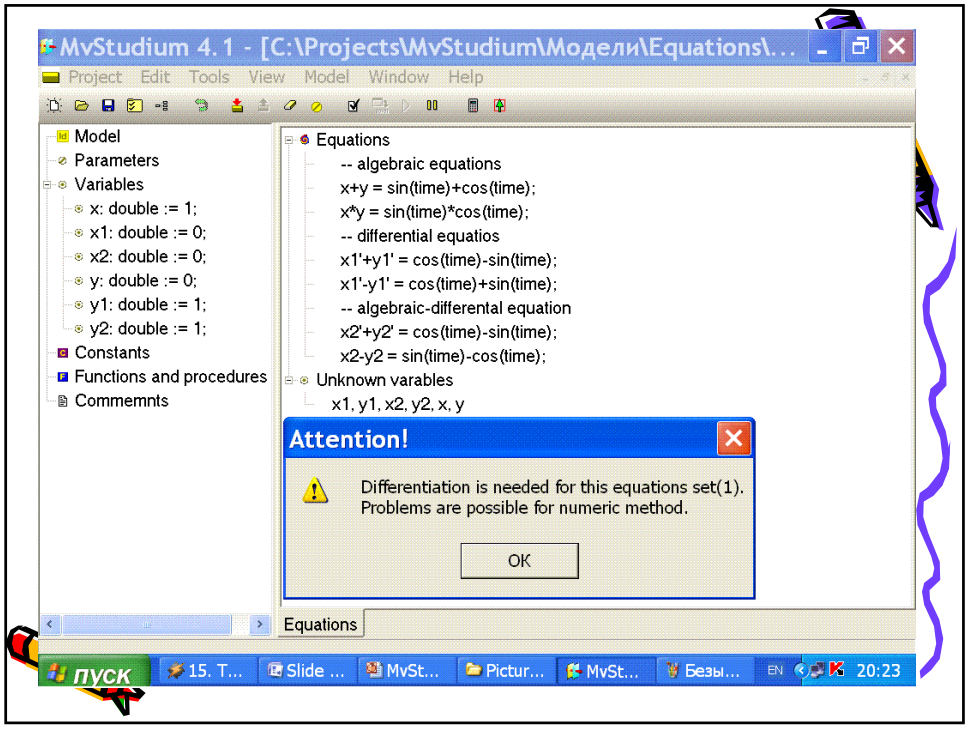


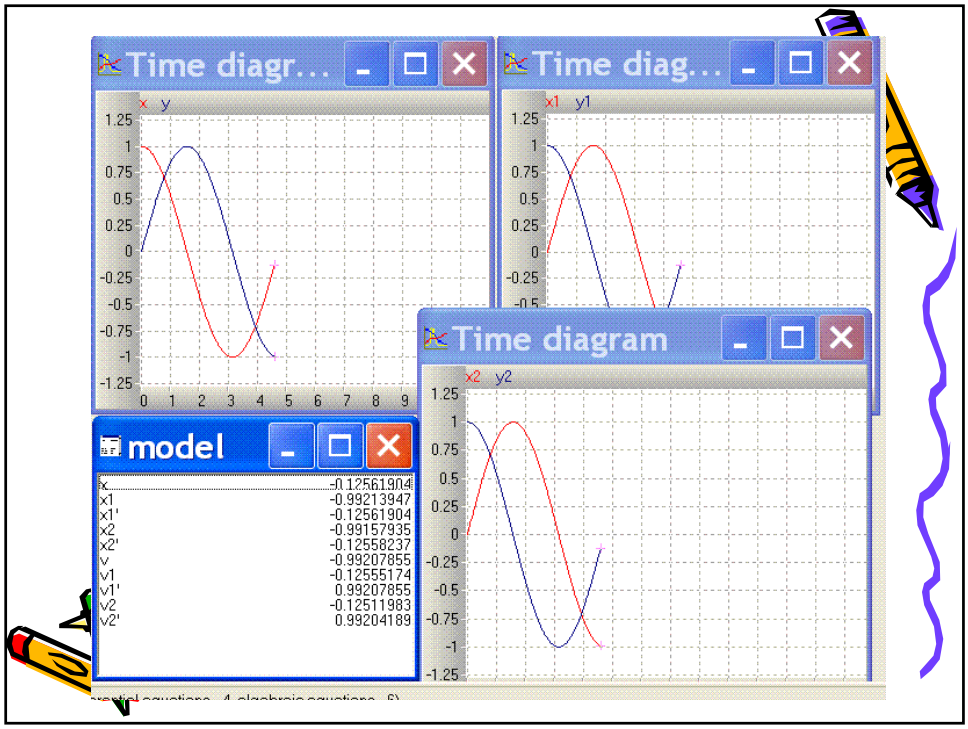




Numerical problems

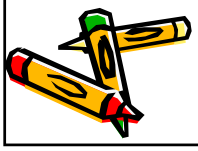
- Nonlinear Algebraic Equations
- Ordinary Differential Equations
- Algebraic-Differential Equations


MvStudium 4.1 - [C:\Projects\MvStudium\Модели\Equations\...
Project Edit Tools View Model Window Help
Model
Parameters
Variables
x: double := 1;
x1: double := 0;
x2: double := 0;
y: double := 0;
y1: double := 1;
y2: double := 1;
Constants
Functions and procedures
Commemnts
Equations
-- algebraic equations
x+y = sin(time)+cos(time);
x*y = sin(time)*cos(time);
-- differential equatios
x1'+y1' = cos(time)-sin(time);
x1'-y1' = cos(time)+sin(time);
-- algebraic-differental equation
x2'+y2' = cos(time)-sin(time);
x2-y2 = sin(time)-cos(time);
Unknown varables
x1, y1, x2, y2, x, y
Attention!
Differentiation is needed for this equations set(1).
Problems are possible for numeric method.
OK
Equations
пуск
20:23


Time diagr...
Time diag...
Time diagram
model
x -0.12561904
x1 -0.99213947
x1' -0.12561904
x2 -0.99157935
x2' -0.12558237
v -0.99207855
v1 -0.12555174
v1' 0.99207855
v2 -0.12511983
v2' 0.99204189

MVS numerical software

- Linpack, Eispack, Sparspak, MA28
- ODEPACK, Dopri5,dopri853, Radau5,Dassel



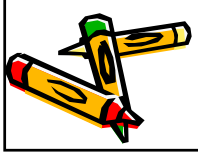
MVS Numerical Library is used

- Fortran version

in
MvStudium 4.x

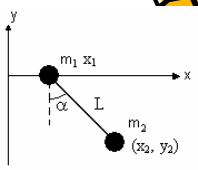
- Java version

in
AnyLogic (Russia)
Open Source Physics (USA)



Examples

Example 1: Pendulum with free point of suspension



Редактор Формул - [cPendMS]

Файл Правка Вставка Вид Помощь

$$(m1+m2)\cdot\frac{d^2 x1}{dt^2}+m2\cdot L\cdot\cos(Alpha)\cdot\frac{d^2 Alpha}{dt^2}-m2\cdot L\cdot\sin(Alpha)\cdot\frac{dAlpha}{dt}^2 = 0$$

$$\cos(Alpha)\cdot\frac{d^2 x1}{dt^2}+L\cdot\frac{d^2 Alpha}{dt^2}+g\cdot\sin(Alpha) = 0$$

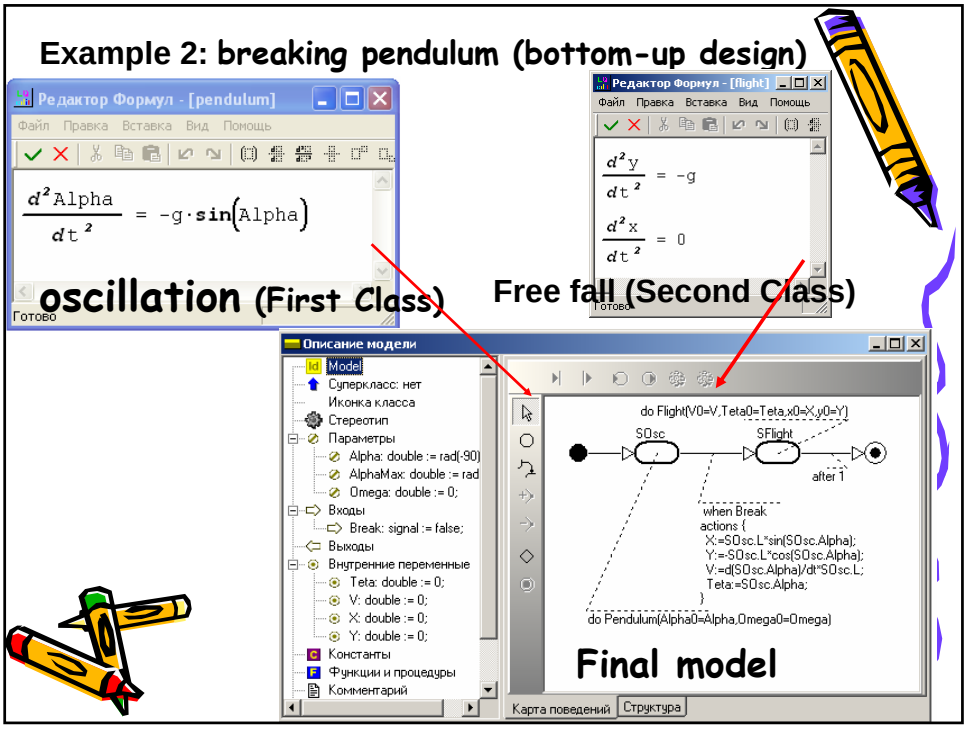
$$x2 = x1+L\cdot\sin(Alpha)$$

$$y2 = -L\cdot\cos(Alpha)$$

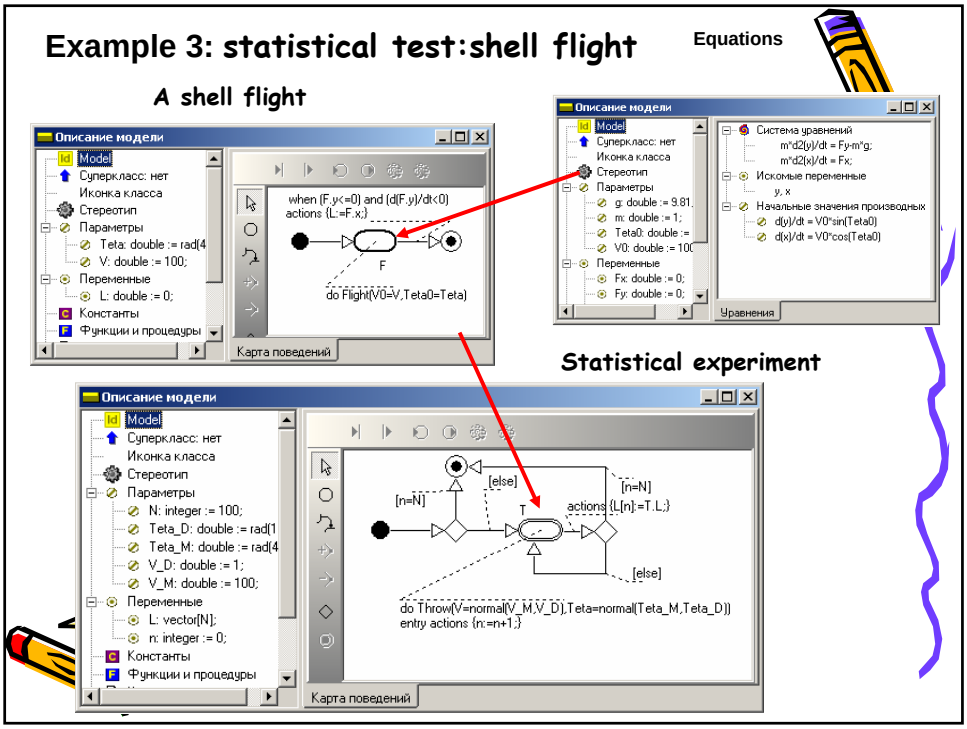
Готово NUM

Editor of mathematics models

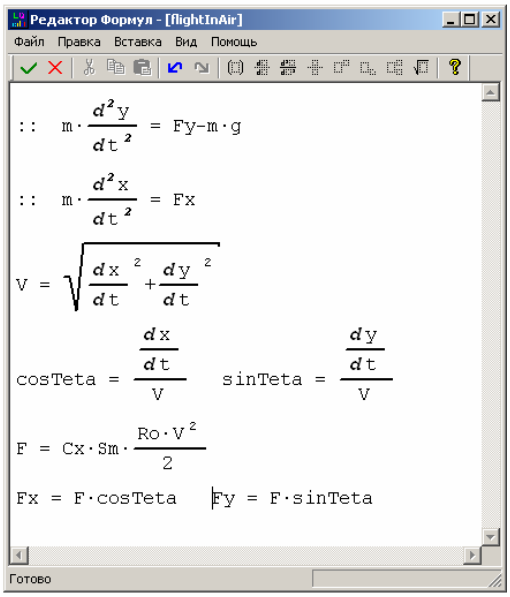
Example 2: breaking pendulum (bottom-up design)



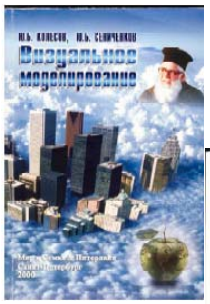
Example 3: statistical test:shell flight



Example 3A: inheritance. Flight without friction and with friction.



Books



Textbooks

Thanks!

http://www.mvstudium.com