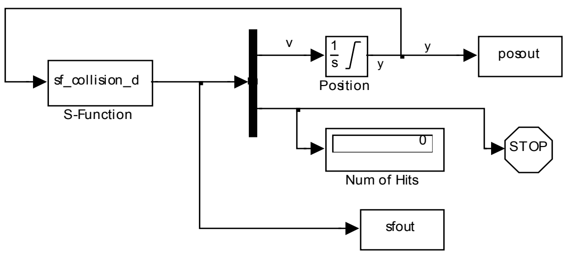
C12 Collision of Spheres – MATLAB / Simulink

Numerical Simulation / Event-oriented Model

Simulator: MATLAB is a widely used software tool based on numuerical vector and matrix manipulation. SIMULINK is a graphical extention for block oriented simulation. S-functions provide a mechanism for extending the capabilities of SIMULINK by adding own blocks. The functionality of these blocks is defined in m-code or C-like programming language.

Model: The main components of the SIMULINK model are the s-function that provides the velocities and times of collisions and an integrator that calculates the positions of the spheres (following pic.).



Since the zero-detection-block is not available in the presence of an s-function, integration was limited to `[0, inf)`. For the s-function an event-driven approach was chosen: using state- (current velocities) and input- (current distances) information the s-function calculates state update and the time when it should be called again (time of next collision).

```
function sys=mdlGetTimeOfNextVarHit(t,v,u,e)
global thit stop hittype
% get time of next collision
v_0=-eps;y_0=realmin;
thit = 0;
hittype = 0;
if (v(2) < v_0) & (u(2) > y_0)
    thit = - u(2) / v(2); hittype = 1;
end
if (v(3) < v_0) & (u(3) > y_0)
…
```

Task a: Figure 1 shows the distance-time function for e=0.2. For e=1 final velocities are $vx_1=vx_2=vx_3=0$ and $vx_4=1$.

The smallest e for which the model is computable is e=0.154504. (quasi-plastic case). Smaller values of e lead to times between two collisions that are smaller than Simulinks minimum timestep (~10^{-14}). In this dimension the collision-model is definitely not valid so no extensions have been made.

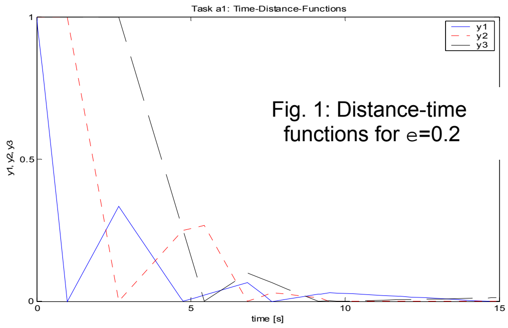


Fig. 1: Distance-time functions for e=0.2

Task b: Figures 2 shows the numbers of collisions and final velocities v_4 for simulation runs with e varied from 1 down to 0.154504.

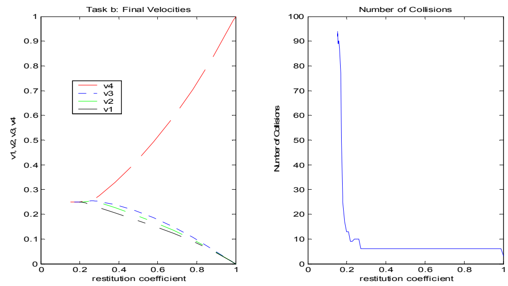


Figure 2: Final Velocities and Number of Hits

Task c: The boundary value problem was solved using the results of task b and cubic interpolation. To get $v_4=v_0/2$ the restitution coefficient has to be e=0.587401.

The statistic parameters obtained from 1000 samples are: mean value: $v_4=0.422762$ standard deviation: s=0.0422665 and 95% confidence interval: $[0.42014 \le \mu \le 0.42539]$

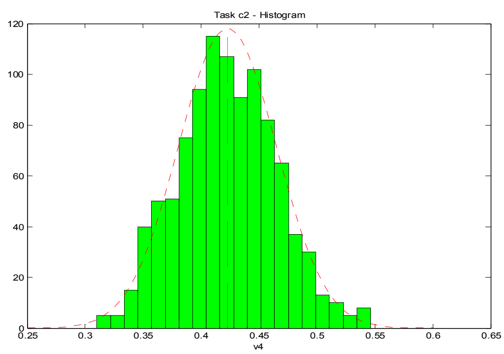


Fig.3: Histogram of final velocity v_4 for e out of N(0.5, 0.005)

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