POČÍTAČOVÉ SIMULACE FYZIKÁLNÍCH PROBLÉMŮ

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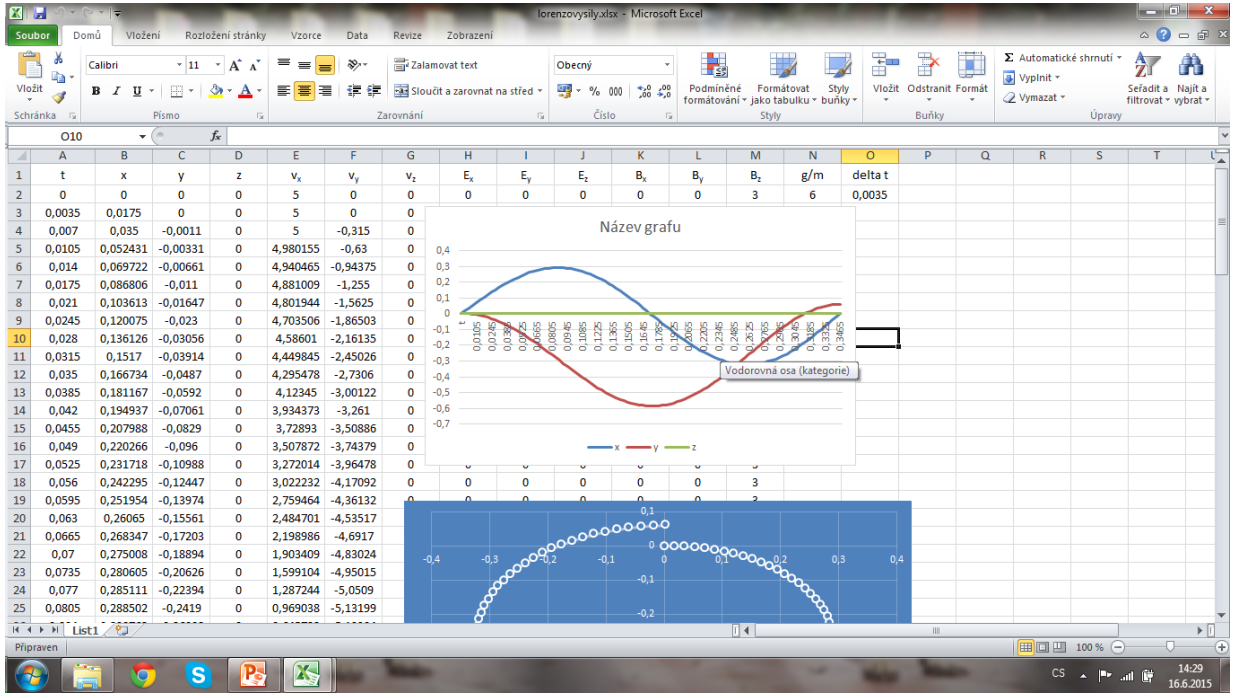
Osnova

1. Úvod
2. Seznámení s programem Wolfram Mathematica 9
3. Lorentzova síla
4. Torricelliho balistická křivka
5. Závěr
6. Poděkování, Zdroje

Úvod

- dva typy řešení rovnic v kartézské soustavě
- Open Source programy
- Closed Source programy



Výpočet Lorentzovy síly v MO Excel

lorentz.nb *

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In[341]:=
```
Ex[t_, x_, y_, z_] := Sin[x];
Ey[t_, x_, y_, z_] := Sin[y];
Ez[t_, x_, y_, z_] := 0;
Bx[t_, x_, y_, z_] := 0;
By[t_, x_, y_, z_] := 0;
Bz[t_, x_, y_, z_] := 1;
equations = {m x''[t] == q (Ex[t, x[t], y[t], z[t]] + y'[t] Bz[t, x[t], y[t], z[t]] - z'[t] By[t, x[t], y[t], z[t]]),
    m y''[t] == q (Ey[t, x[t], y[t], z[t]] + z'[t] Bx[t, x[t], y[t], z[t]] - x'[t] Bz[t, x[t], y[t], z[t]]),
   m z''[t] == q (Ez[t, x[t], y[t], z[t]] + x'[t] By[t, x[t], y[t], z[t]] - y'[t] Bx[t, x[t], y[t], z[t]]), x[0] == 0, y[0] == 0, z[0] == 0,
   x'[0] == 1, y'[0] == 0, z'[0] == 0.1} /. {m → 1, q → 2}
solution = NDSolve[equations, {x, y, z}, {t, 0, 100}]
```

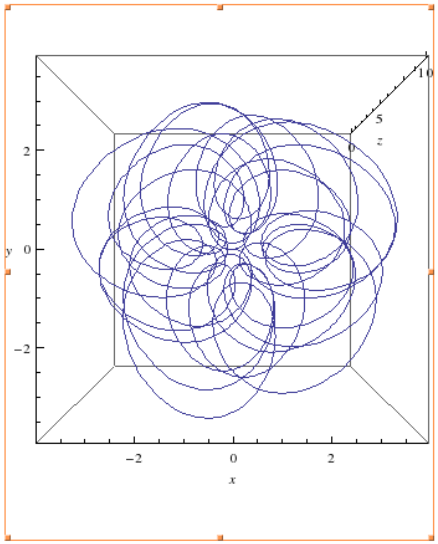
Out[347]=
```
{x''[t] == 2 (Sin[x[t]] + y'[t]), y''[t] == 2 (Sin[y[t]] - x'[t]), z''[t] == 0, x[0] == 0, y[0] == 0, z[0] == 0, x'[0] == 1, y'[0] == 0, z'[0] == 0.1}
```

Out[348]=
```
{{x → InterpolatingFunction[{{0., 100.}}, <>], y → InterpolatingFunction[{{0., 100.}}, <>], z → InterpolatingFunction[{{0., 100.}}, <>]}}

{{x → InterpolatingFunction[{{0., 100.}}, <>], y → InterpolatingFunction[{{0., 100.}}, <>], z → InterpolatingFunction[{{0., 100.}}, <>]}}
```

In[349]:=
```
ParametricPlot3D[Evaluate[{x[t], y[t], z[t]} /. solution], {t, 0, 100}, AxesLabel → {x, y, z}]
```

Out[349]=



In[248]:=
```
Plot3D[Cos[x] - Cos[y], {x, -5, 5}, {y, -5, 5}, AxesLabel → {x, y, z}]
```

100%

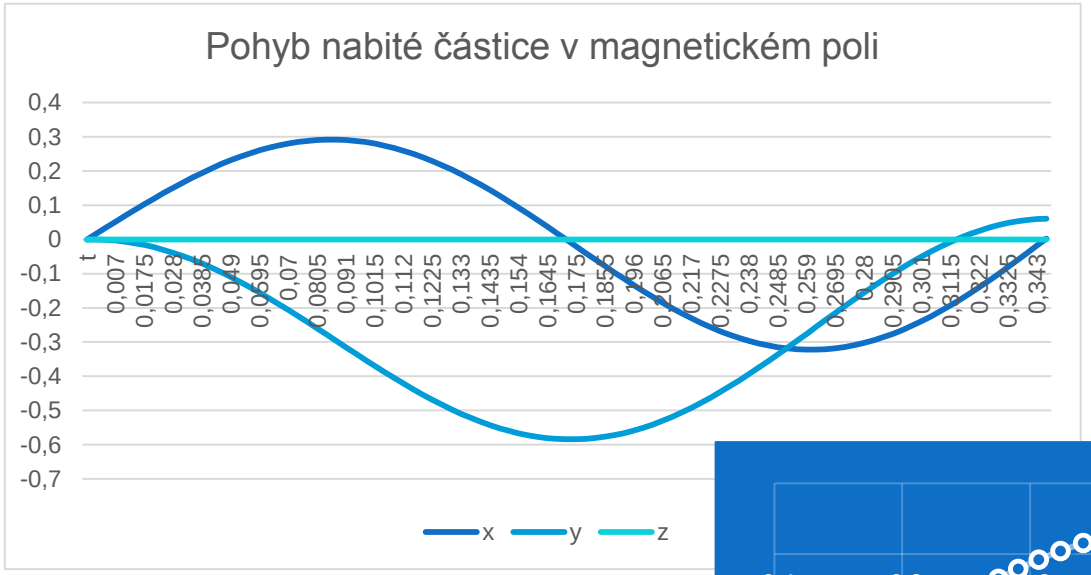
Výpočet Lorentzovy síly v Mathematica

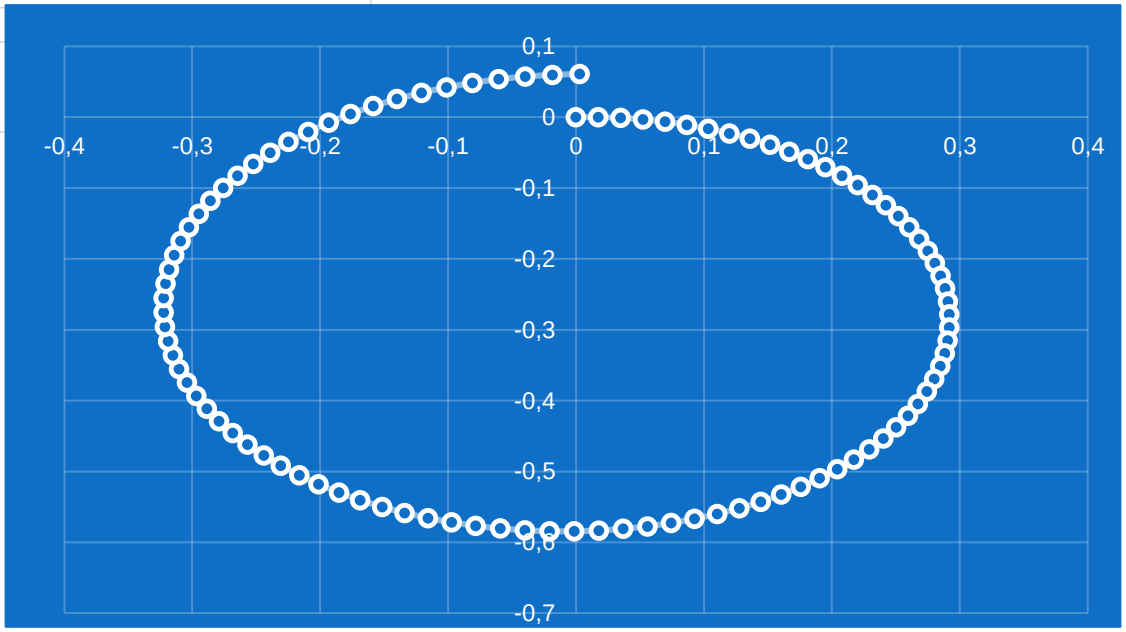
Lorentzovy rovnice

$$\boldsymbol{m} * \ddot{\vec{\boldsymbol{x}}}(\boldsymbol{t}) = \boldsymbol{q}\left(\vec{\boldsymbol{E}}(\boldsymbol{x},\boldsymbol{t}) + \vec{\boldsymbol{v}}(\boldsymbol{t}) * \vec{\boldsymbol{B}}(\boldsymbol{x},\boldsymbol{t})\right)$$

$$m * \ddot{x}(t) = q\big(E_y(x,t) + v_y B_z(x,t) - v_z B_y(x,t)\big)$$
$$m * \ddot{y}(t) = q\big(E_z(y,t) + v_z B_x(y,t) - v_x B_z(y,t)\big)$$
$$m * \ddot{z}(t) = q\big(E_x(z,t) + v_x B_y(z,t) - v_y B_x(z,t)\big)$$
$$g(t) = \ddot{\vec{x}}(t)$$
$$f(t + 2\Delta t) = (\Delta t)^2 * g(t) + 2f(t + \Delta t) - f(t)$$

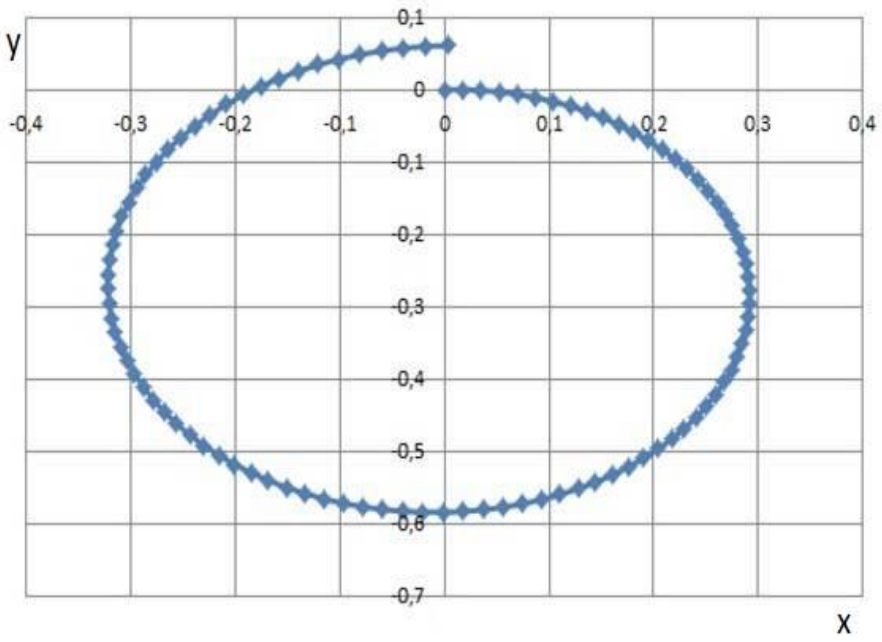
Výsledky (1)



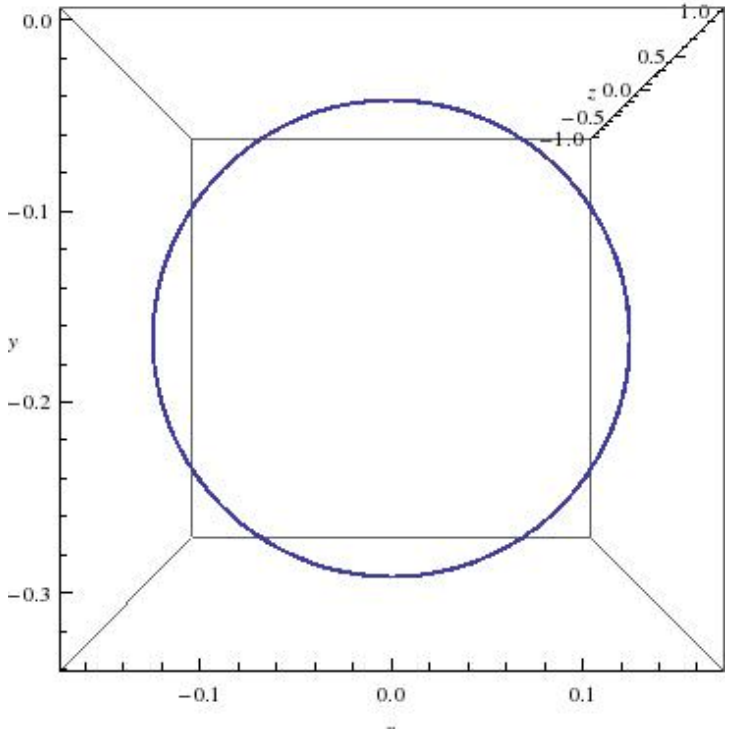


Grafy Lorentzovy síly v MO Excel

Porovnání přesnosti metod

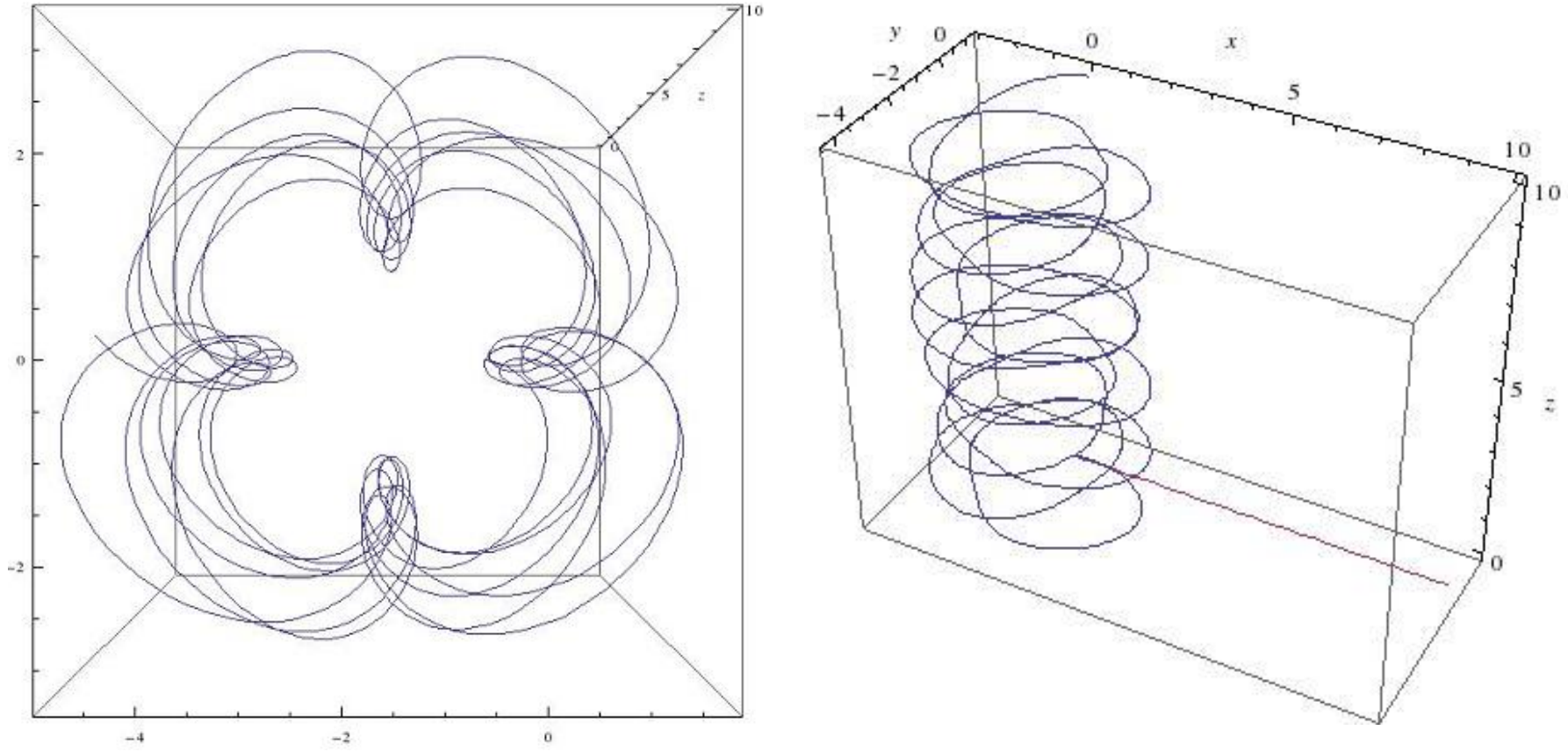


Graf Lorentzovy síly v MO Excel



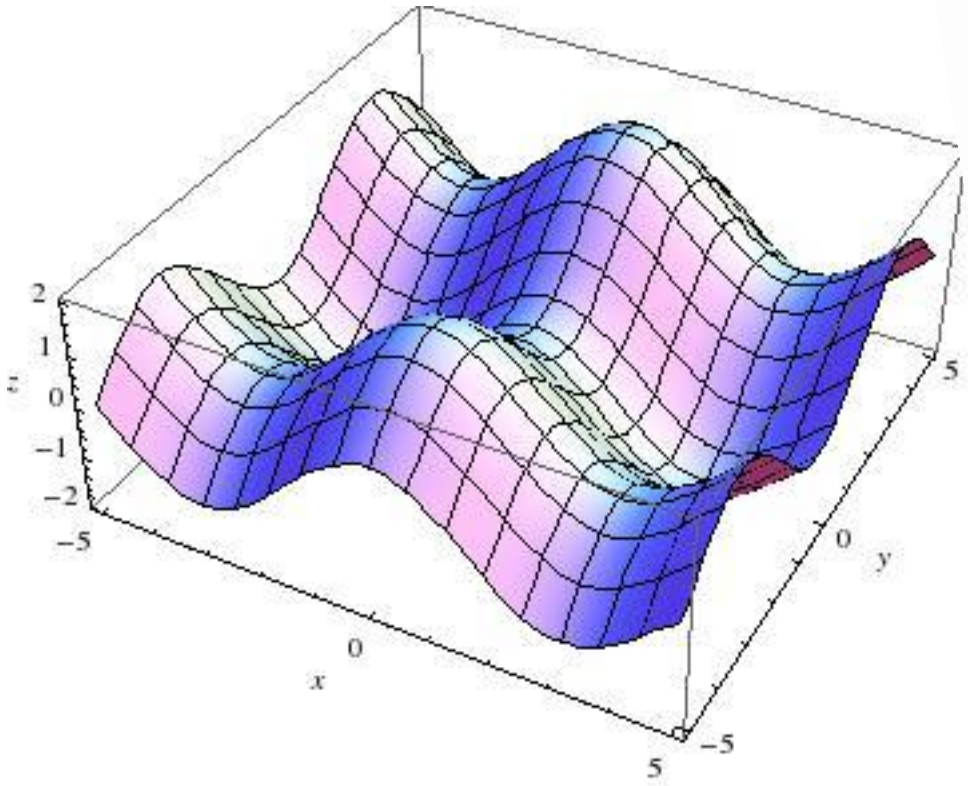
Graf Lorentzovy síly ve Wolfram Mathematica 9

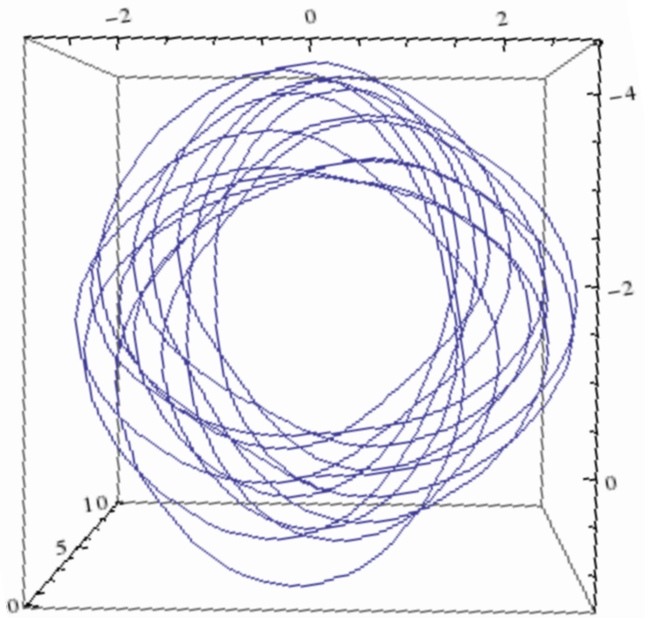
Výsledky (2)



Grafy Lorentzovy síly ve Wolfram Mathematica 9

Výsledky (3)



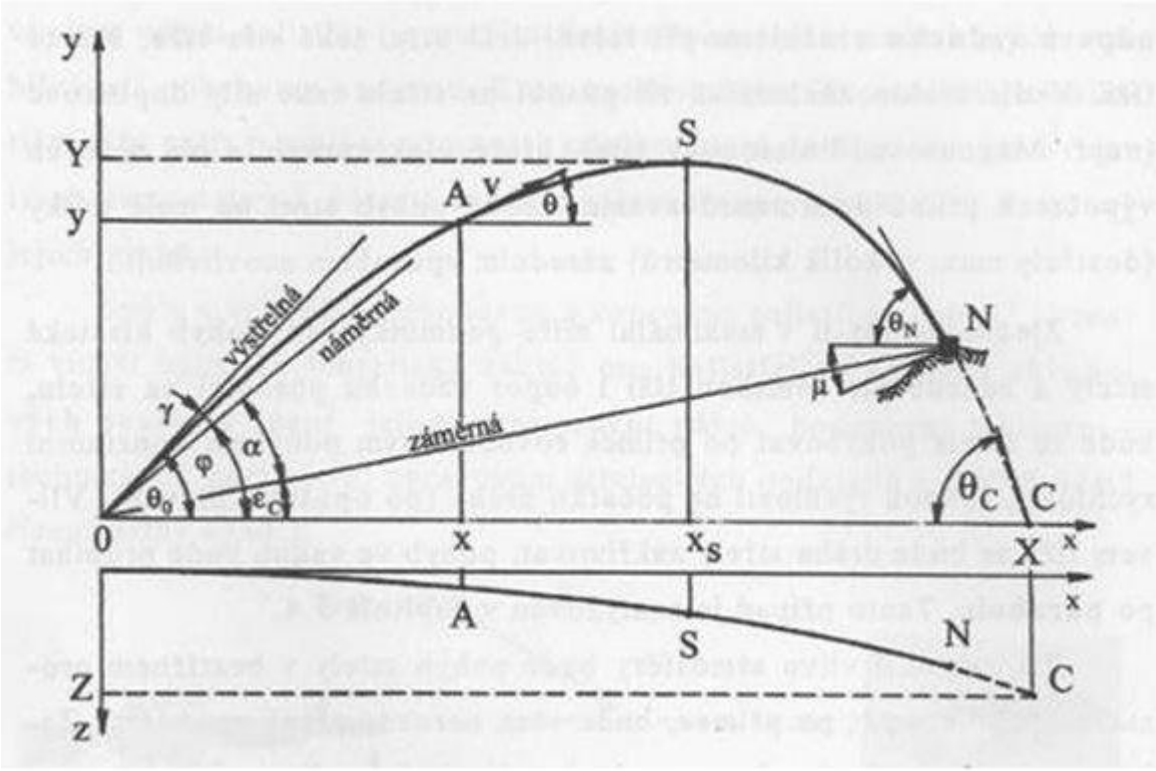


Grafy Lorentzovy síly ve Wolfram Mathematica 9

Torricelliho balistická křivka

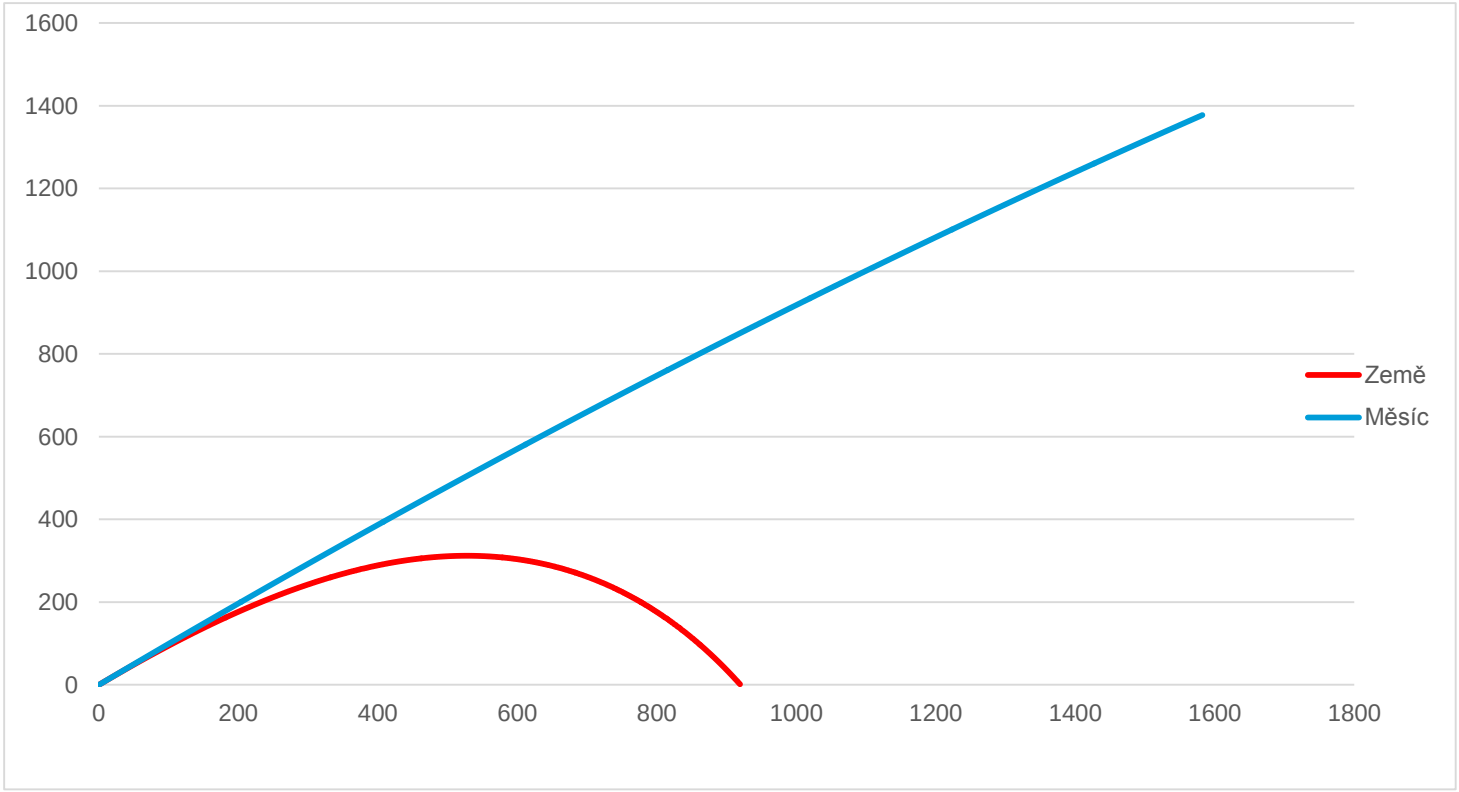
$$M\ddot{\vec{x}} = \vec{F} + \vec{F}_{od}$$

$$M\ddot{\vec{x}} = -m\vec{K} - \frac{1}{2}CS\rho\left|\dot{\vec{x}}\right| * \dot{\vec{x}}$$



Obecný nákres Torricelliho křivky

Výsledky (4)



Grafy trajektorie střely v MO Excel

Závěr

- výsledný pohyb částice v elektromagnetickém poli
- trajektorie střely ve vakuu a ve vzduchu
- délky dostřelu dělové koule na Zemi a na Měsíci
- pohyb částic v plazmatu

Poděkování, Zdroje

- FJFI ČVUT
- garant Ing. Hynek Lavička, Ph.D.
- supervizor Ing. Vojtěch Svoboda, CSc.

Zdroje:

[1] Lorentzova síla. *Wikipedia: the free encyclopedia* [online]. San Francisco (CA): Wikimedia Foundation, 2001- [cit. 2015-06-16]. Dostupné z: https://cs.wikipedia.org/wiki/Lorentzova_s%C3%ADla

[2] GRIFFITHS, D a Desmond J HIGHAM. *Numerical methods for ordinary differential equations: initial value problems*. x, 271 pages. ISBN 978-0-85729-147-9.