Raptor Problem

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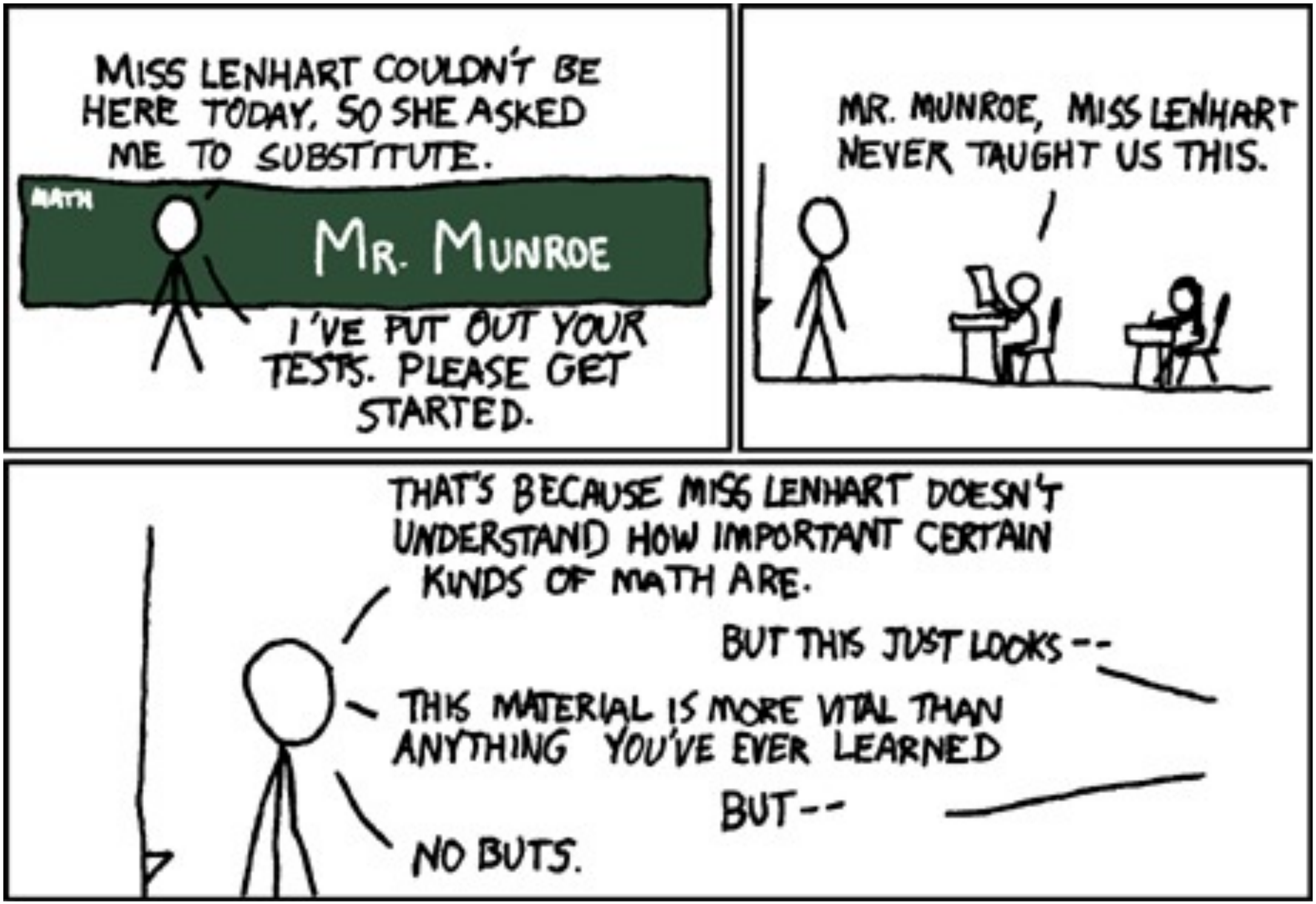
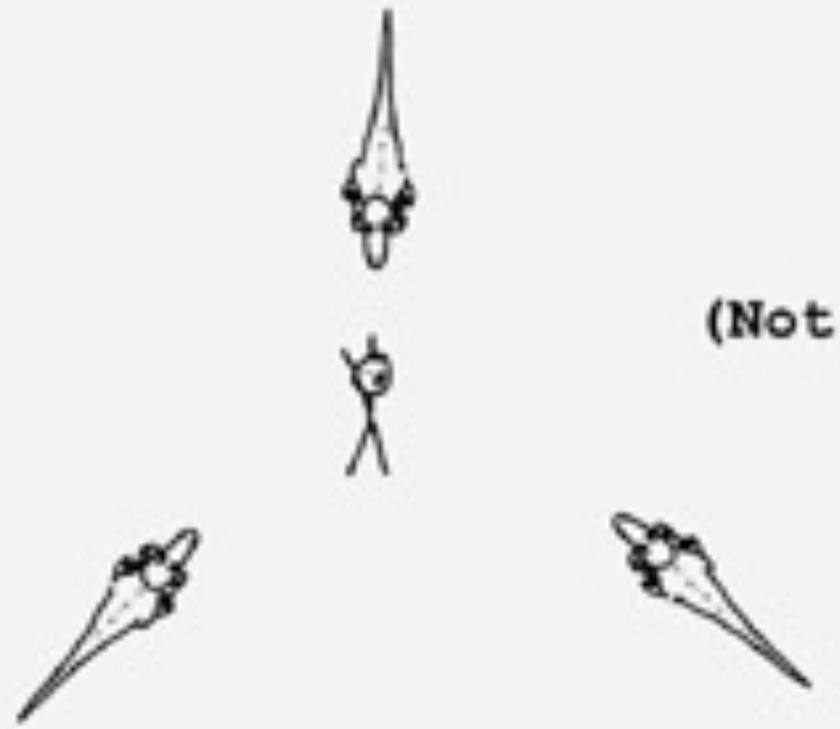


Source: http://xkcd.com/135/

The problem

2. You are at the center of a 20m equilateral triangle with a raptor at each corner. The top raptor has a wounded leg and is limited to a top speed of 10 m/s.



(Not to scale)

The raptors will run toward you. At what angle should you run to maximize the time you stay alive?

THIS IS A MATTER OF LIFE AND DEATH.

The model

choose angle to run θ

to maximize survival time T

subject to raptor motion $$\frac{d\mathbf{r}_i}{dt}(t) = v_i \frac{\mathbf{p}(t) - \mathbf{r}_i(t)}{\|\mathbf{p}(t) - \mathbf{r}_i(t)\|}$$

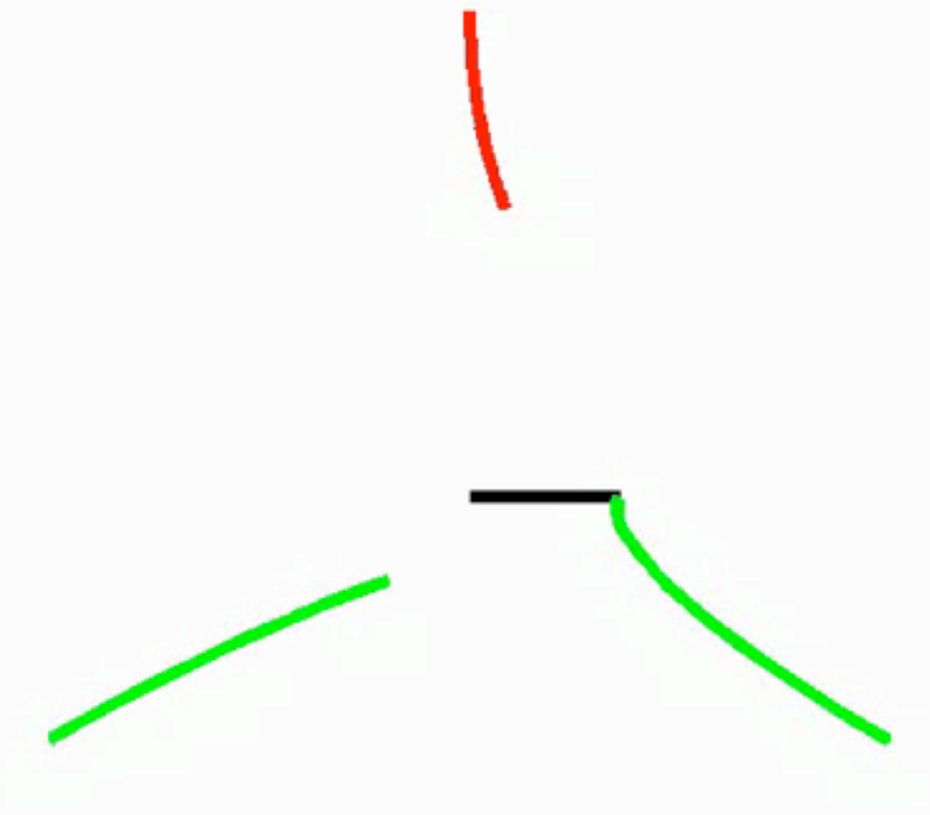
human motion $$\frac{d\mathbf{p}}{dt}(t) = v_p \begin{bmatrix} \cos(\theta) \\ \sin(\theta) \end{bmatrix}$$

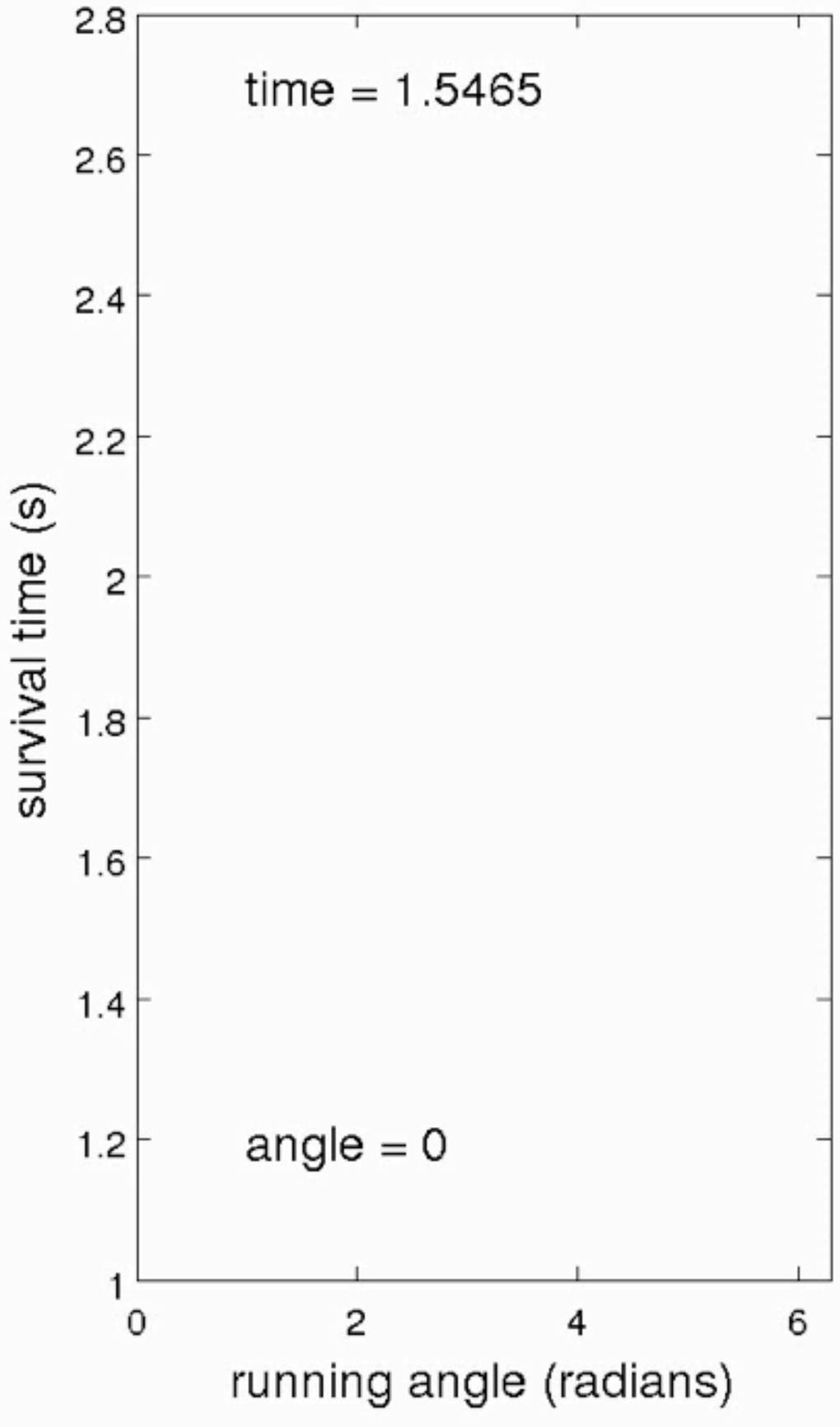
getting caught $$\|\mathbf{p}(T) - \mathbf{r}_i(T)\| \leq \delta$$

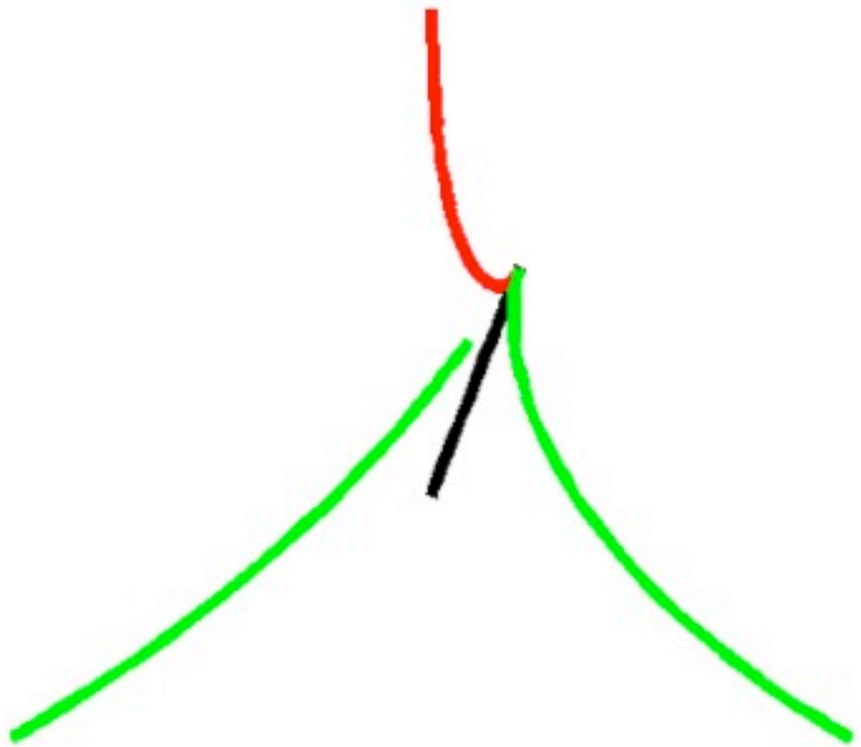
Single parameter optimization

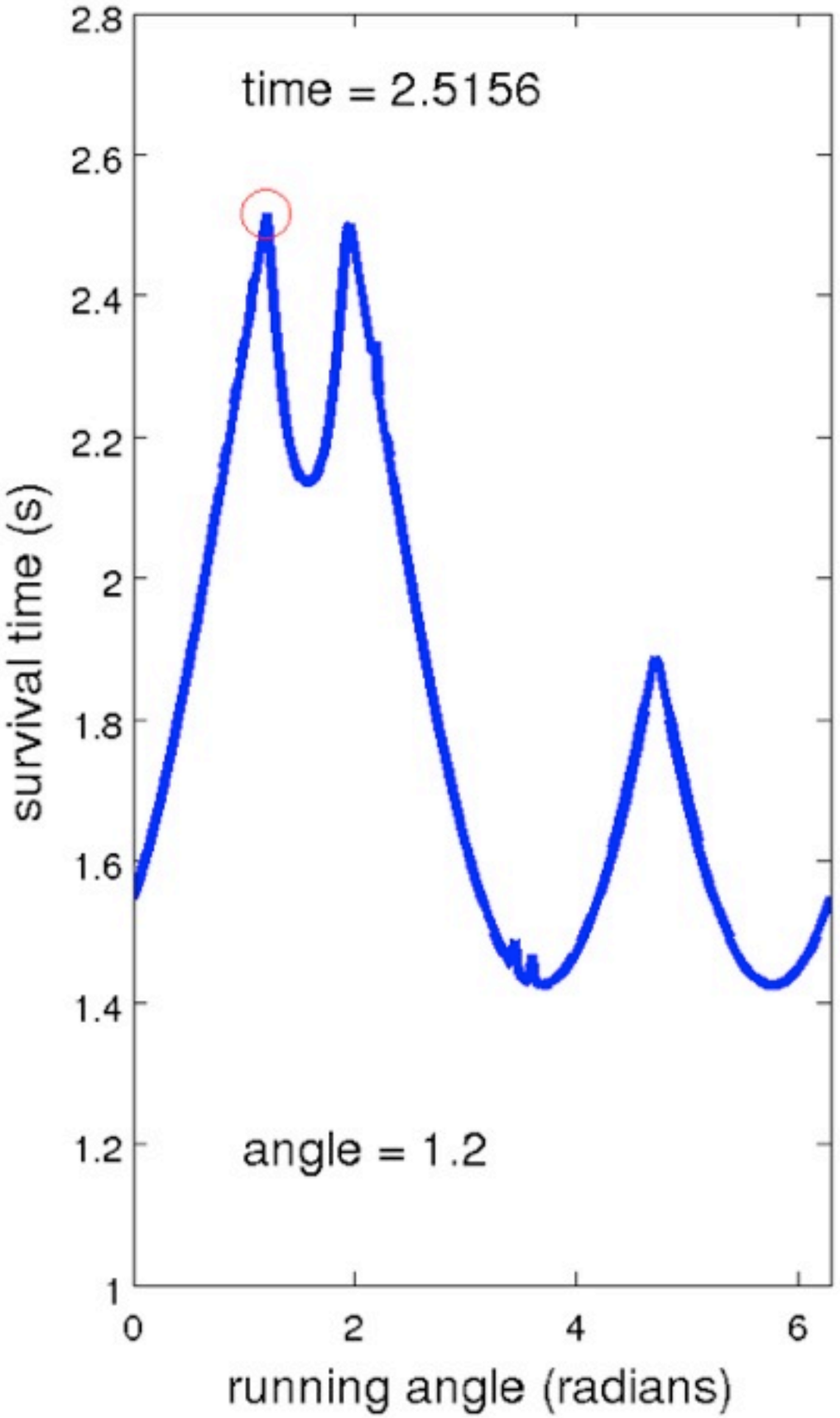
- Sample over range of angles
- Choose the angle that gives largest survival time
- Simulation uses Matlab's ode45

Simulate!




time = 1.5465
survival time (s)
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
angle = 0
0
2
4
6
running angle (radians)




time = 2.5156
angle = 1.2
survival time (s)
running angle (radians)
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0
2
4
6

Can we do better?

The new model

choose direction to run $\mathbf{v}_p(t)$

to minimize "likelihood" of being eaten

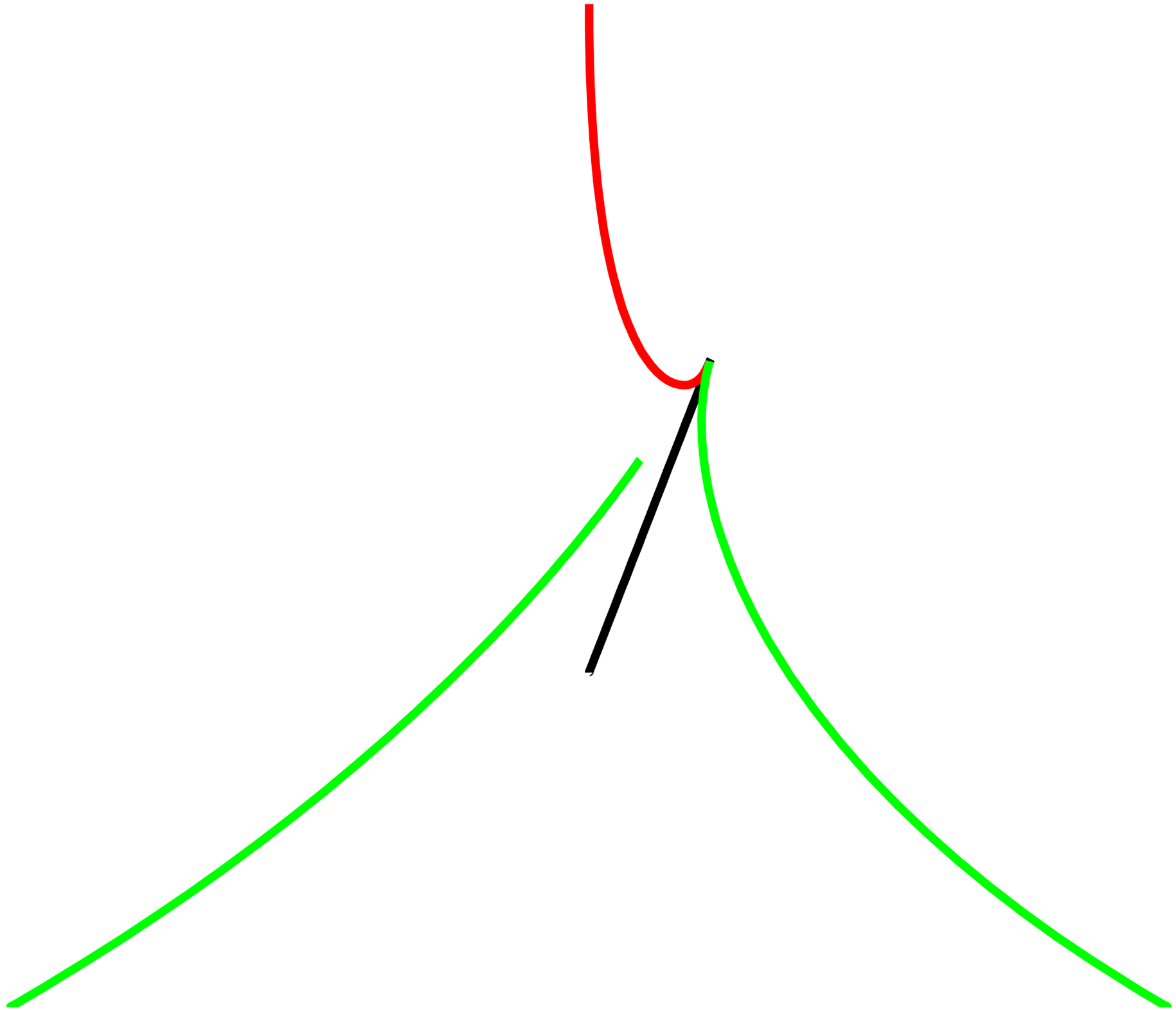
$$\int_0^T \sum_{i=1}^{3} \frac{1}{\|\mathbf{p}(t) - \mathbf{r}_i(t)\|^2} dt$$

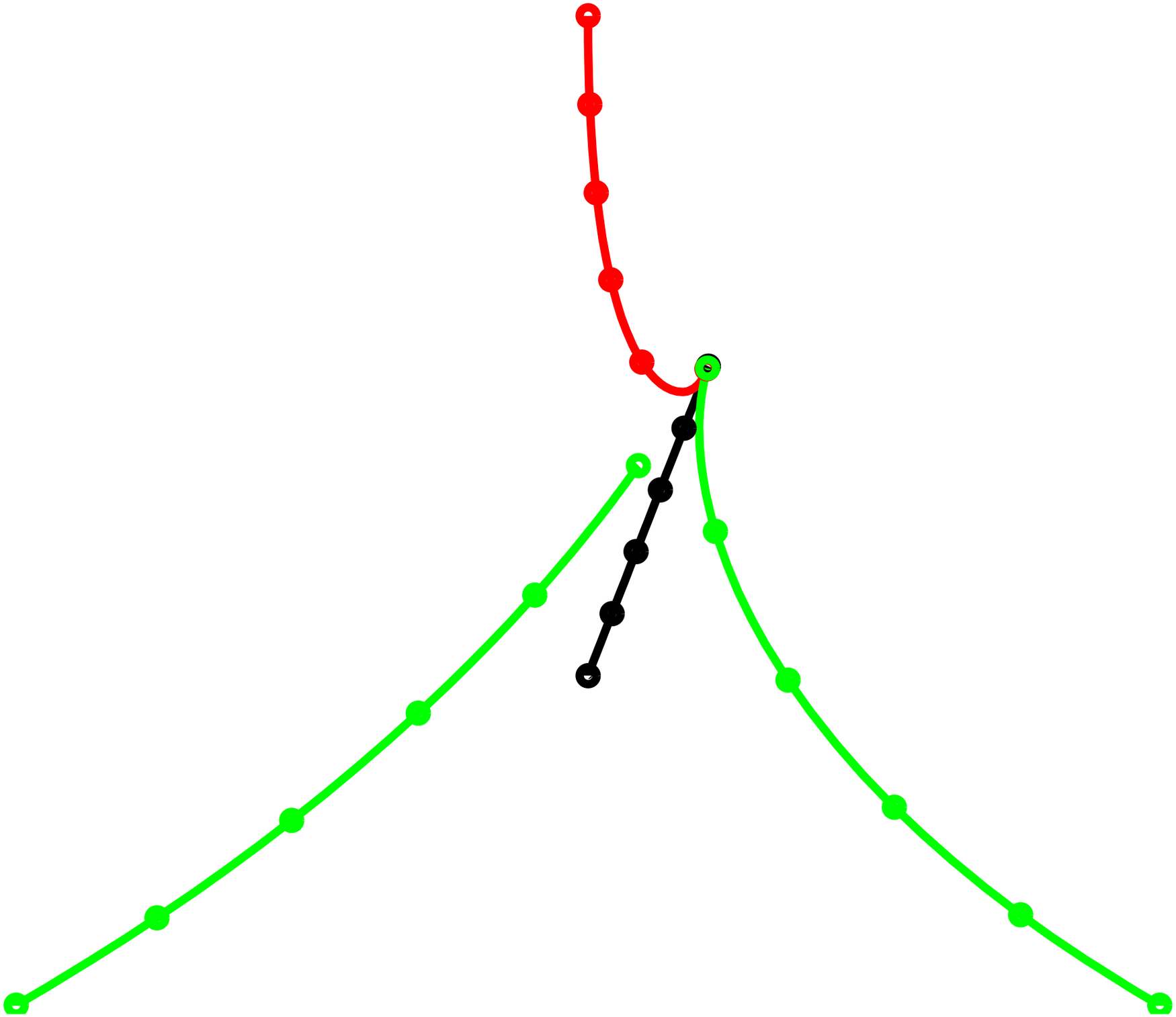
subject to raptor motion

$$\frac{d\mathbf{r}_i}{dt}(t) = v_i \frac{\mathbf{p}(t) - \mathbf{r}_i(t)}{\|\mathbf{p}(t) - \mathbf{r}_i(t)\|}$$

human motion

$$\frac{d\mathbf{p}}{dt}(t) = \mathbf{v}_p(t)$$





The new model

choose direction to run $\mathbf{v}_p[j]$ for $j = \{1, \ldots, N\}$

to minimize "likelihood" of being eaten

$$\sum_{j=1}^{N} \sum_{i=1}^{3} \frac{1}{\|\mathbf{p}[j] - \mathbf{r}_i[j]\|^2} dt$$

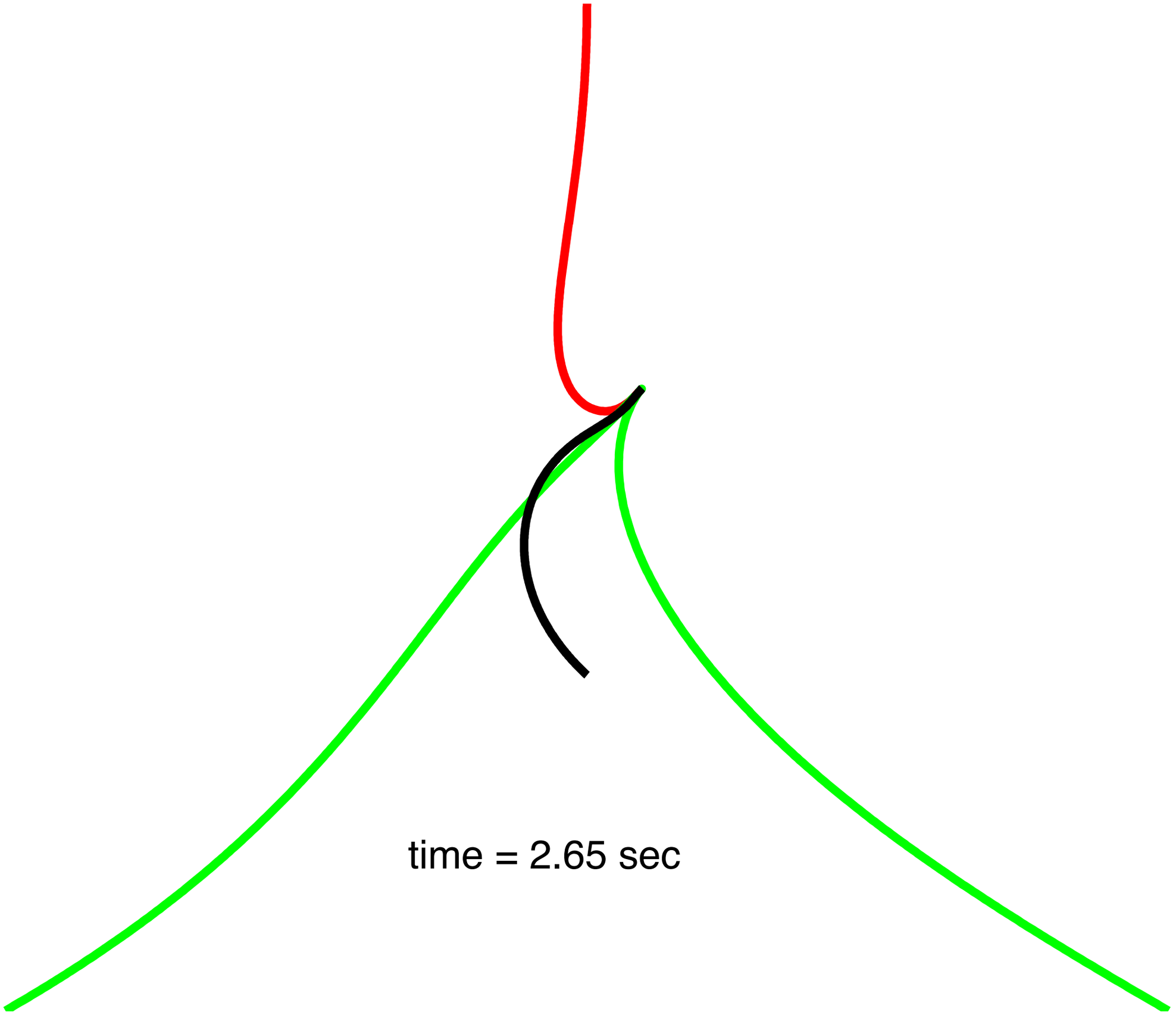
subject to raptor motion

$$\mathbf{r}_i[j+1] = \mathbf{r}_i[j] + h v_i \frac{\mathbf{p}[j] - \mathbf{r}_i[j]}{\|\mathbf{p}[j] - \mathbf{r}_i[j]\|}$$

human motion

$$\mathbf{p}[j+1] = \mathbf{p}[j] + h\mathbf{v}_p[j]$$

Solve!



time = 2.65 sec