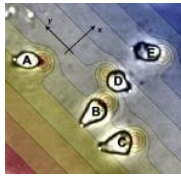
Physics 131-Physics for Biologists I



Professor: Wolfgang Losert
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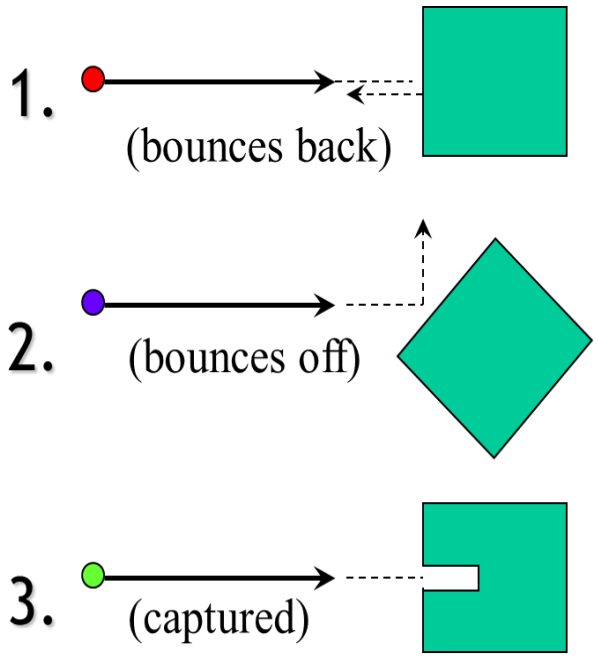
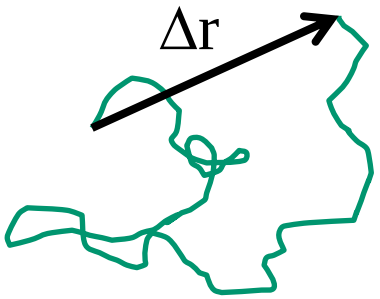
Midterm 2: November 8

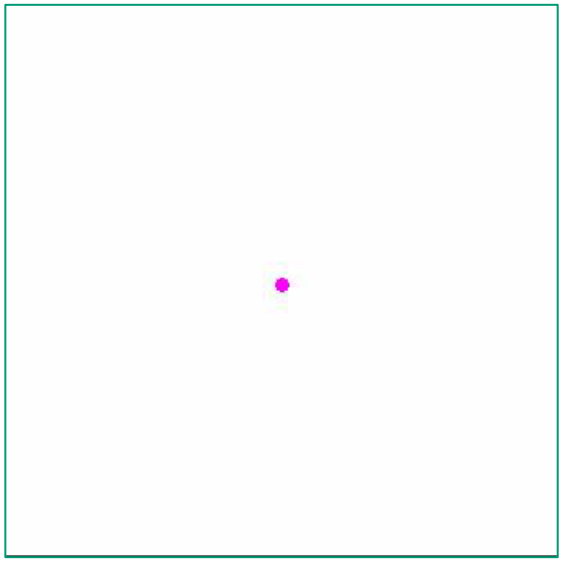
Office Hours before Midterm 2:
Course Center: Monday Nov 4, 11am-12.30pm
3341 AV Williams: Wednesday Nov 6, 11.30am-1pm

Quiz 7: Average 6



Random Motion in two dimensions





Alex Morozov &
Kerstin Nordstrom

If I wait four times as long, the (green) trajectory is on average longer by a factor ___?

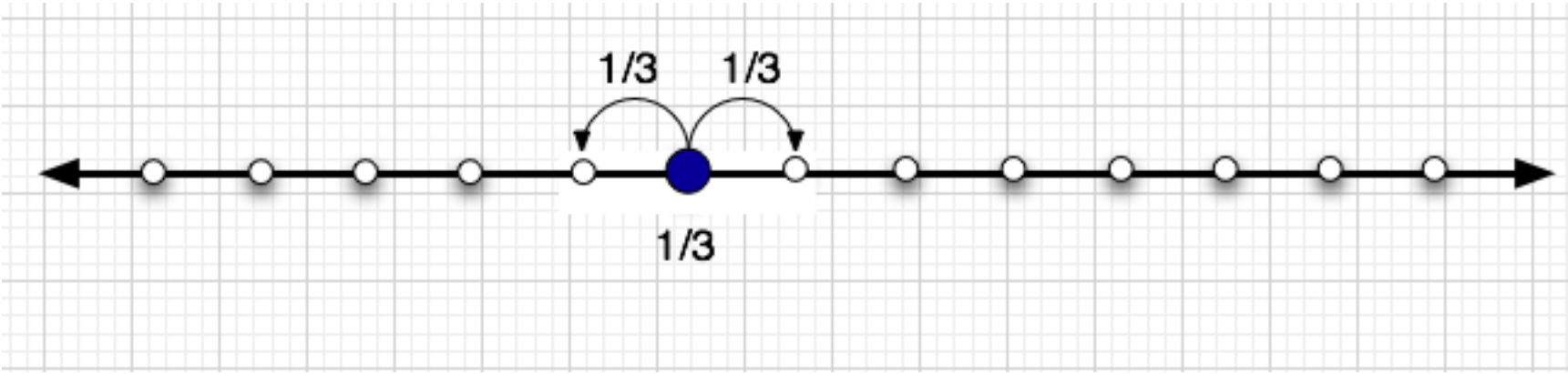
If I wait four times as long, the distance between start and end point Δr is on average longer by a factor _____?

$$\left\langle (\Delta r)^2 \right\rangle = 4D\Delta t$$

D is called *the* ***diffusion constant*** and has dimensionality [*D*] = L^2/T

What is the diffusion constant for the following process?

HINT: The motion is already random on ONE step



Distance traveled in one step: 1 nm

Time taken for one iteration: 1 ns

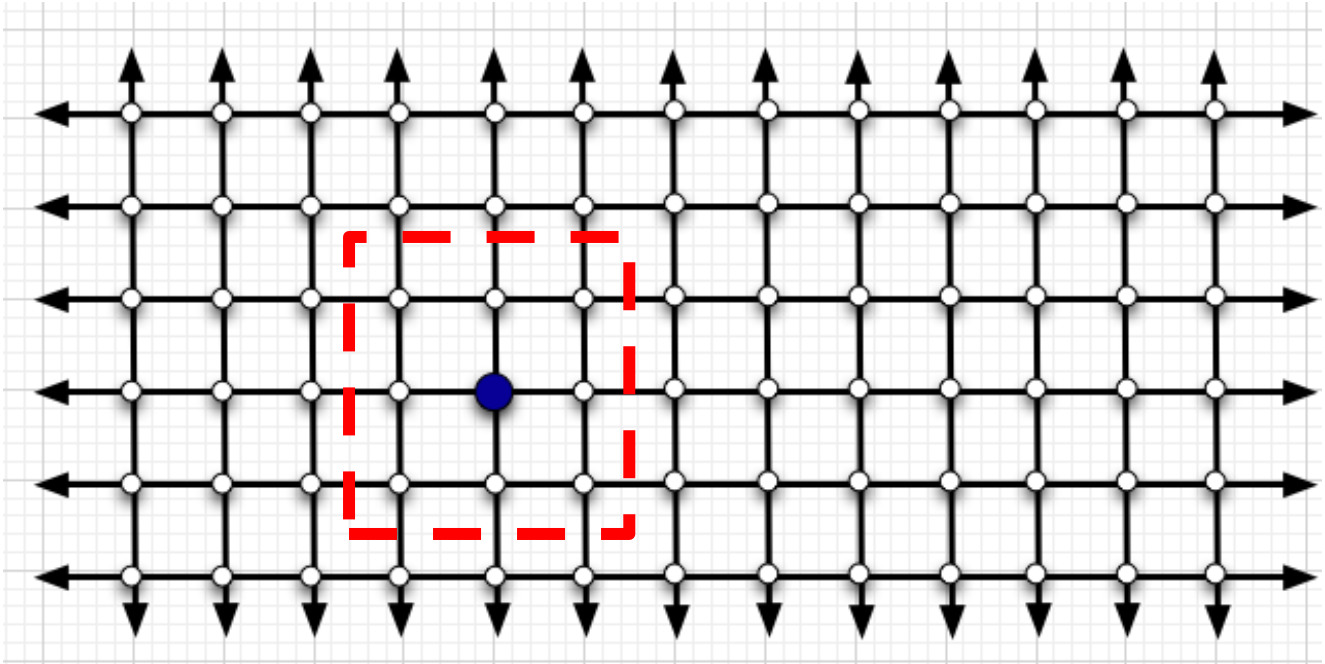
$$1Dimension: \left\langle (\Delta r)^2 \right\rangle = 2D\Delta t$$

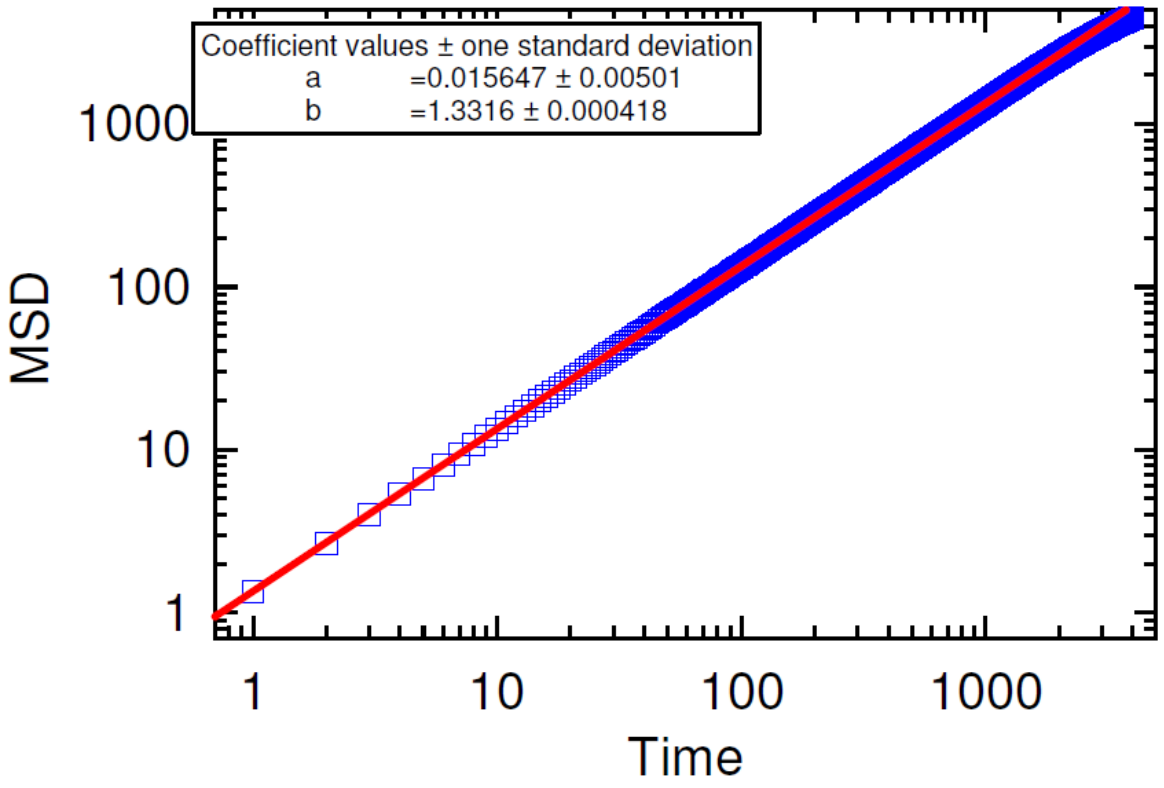
Diffusion Constant: 1/3 nm²/ns

Whiteboard, TA & LA

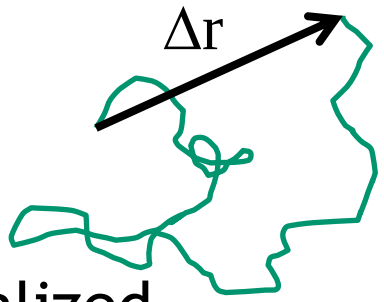
Compared to a 1D random walk if the walker can in addition also take a step in the second dimension following the same rules, the following is true about the Diffusion Constant D and the distance squared traveled $\langle \Delta r^2 \rangle$

1. **$\langle \Delta r^2 \rangle$ is larger by factor 2**
2. $\langle \Delta r^2 \rangle$ is larger by factor $\sqrt{2}$
3. $\langle \Delta r^2 \rangle$ is the same
4. $\langle \Delta r^2 \rangle$ is smaller by factor $\sqrt{2}$
5. $\langle \Delta r^2 \rangle$ is smaller by factor 2




Coefficient values ± one standard deviation
a =0.015647 ± 0.00501
b =1.3316 ± 0.000418
MSD
1000
100
10
1
1
10
100
1000
Time

Random walk in 2D



- As a result of random motion, an initially localized distribution will spread out, getting wider and wider. This phenomenon is called *diffusion*
- The square of the average distance traveled during random motion will grow with time.

- In two dimensions: $\left\langle (\Delta r)^2 \right\rangle = 4D\Delta t$
- 1D: $\left\langle (\Delta x)^2 \right\rangle = 2D\Delta t$ 3D: $\left\langle (\Delta r)^2 \right\rangle = 6D\Delta t$