Physics 131-Physics for Biologists I

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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

1. (bounces back)

2. (bounces off)

3. (captured)
Random Motion in two dimensions

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 $\Delta r$ is on average longer by a factor ____?

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

$D$ 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
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

- $a = 0.015647 \pm 0.00501$
- $b = 1.3316 \pm 0.000418$
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: \[ \langle (\Delta r)^2 \rangle = 4D\Delta t \]

- 1D: \[ \langle (\Delta x)^2 \rangle = 2D\Delta t \]

- 3D: \[ \langle (\Delta r)^2 \rangle = 6D\Delta t \]