PhysicsByAaryan

CSIR NET . GATE . JEST . BARC - Physics

Random Walk/Brownian motion/Diffusion - CSIR NET Physics PYQs

Statistical Mechanics . All PYQs (2015-2025) with answer key

15 questions . Answer key included

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Q1. [Dec 2015] . 5.0 marks

Statistical Mechanics > Random Walk/Brownian motion/Diffusion

CSIR NET	2015 Dec	5 M

Consider a random walker on a square lattice. At each step the walker moves to a nearest neighbour site with equal probability for each of the four sites. The walker starts at the origin and takes 3 steps. The probability that during this walk no site is visited more than one is

1. $12/27$
2. $27/64$
3. $3/8$
4. $9/16$

Q2. [June 2015] . 5.0 marks

Statistical Mechanics > Random Walk/Brownian motion/Diffusion

CSIR NET	2015 June	5 M

A large number N of Brownian particles in one dimension start their diffusive motion from the origin at time $t = 0$. The diffusion coefficient is D. The number of particles crossing a point at a distance L from the origin, per unit time, depends on L and time t as

1. $\frac{N}{\sqrt{4\pi Dt}} e^{-L^2/(4Dt)}$

2. $\frac{NL}{\sqrt{4\pi Dt}} e^{-4Dt/L^2}$

3. $\frac{N}{\sqrt{16\pi Dt^3}} e^{-L^2/(4Dt)}$

4. Ne^{-4Dt/L^2}

Q3. [Dec 2016] . 3.5 marks

Statistical Mechanics > Random Walk/Brownian motion/Diffusion

CSIR NET	2016 Dec	3.5M

Consider a continuous time random walk. If a step has taken place at time $t = 0$, the probability that the next step takes place between t and $t + dt$ is given by $btdt$, where b is a constant. What is the average time between successive steps?

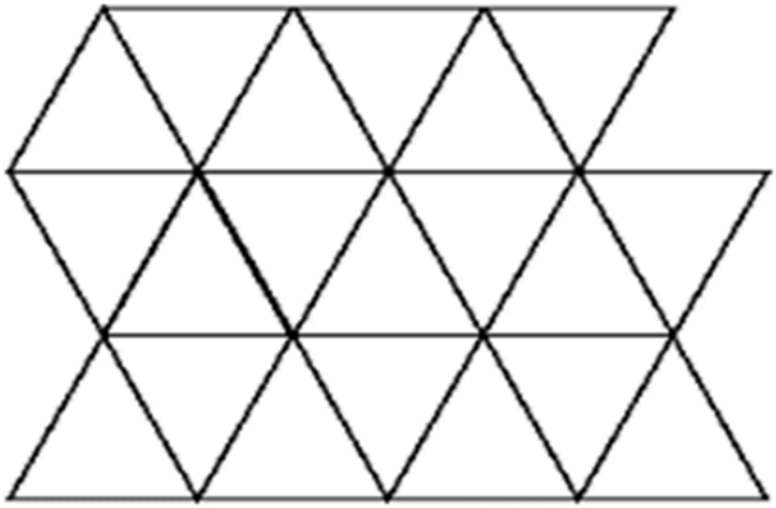
1. $\sqrt{\frac{2\pi}{b}}$
2. $\sqrt{\frac{\pi}{b}}$
3. $\frac{1}{2}\sqrt{\frac{\pi}{b}}$
4. $\sqrt{\frac{\pi}{2b}}$

Q4. [Dec 2016] . 5.0 marks

Statistical Mechanics > Random Walk/Brownian motion/Diffusion

CSIR NET	2016 Dec	5M

Consider a random walk on an infinite twodimensional triangular lattice, a part of which is shown in the figure below. If the probabilities of moving to any of the nearest neighbour sites are equal, what is the probability that the walker returns to the starting position at the end of exactly three steps?



1. $\frac{1}{36}$
2. $\frac{1}{216}$
3. $\frac{1}{18}$
4. $\frac{1}{12}$

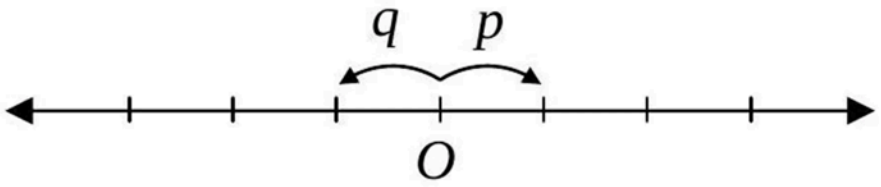
Q5. [Dec 2018] . 5.0 marks

Statistical Mechanics > Random Walk/Brownian motion/Diffusion

CSIR NET	2018 Dec	5M

A particle hops on a one-dimensional lattice with lattice spacing a. The probability of the particle to hop to the neighboring site to its right is p, while the corresponding probability to hop to the left is $q = 1 - p$. The root-mean squared deviation $\Delta x = \sqrt{\langle x^2 \rangle - \langle x \rangle^2}$ in displacement after N steps, is

1. $a\sqrt{Npq}$
2. $aN\sqrt{pq}$
3. $2a\sqrt{Npq}$
4. $a\sqrt{N}$



Q6. [June 2018] . 5.0 marks

Statistical Mechanics > Random Walk/Brownian motion/Diffusion

CSIR NET	2018 June	5M

Consider a particle diffusing in a liquid contained in a large box. The diffusion constant of the particle in the liquid is $1.0 \times 10^{-2}\ \mathrm{cm}^2/\mathrm{s}$. The minimum time after which the root-mean-squared displacement becomes more than $6cm$ is

1. 10 min
2. 6 min
3. 30 min
4. $\sqrt{6}$ min

Q7. [Dec 2019] . 5.0 marks

Statistical Mechanics > Random Walk/Brownian motion/Diffusion

CSIR NET	2019 Dec	5M

A particle hops randomly from a site to its nearest neighbour in each step on a square lattice of unit lattice constant. The probability of hopping to the positive x-direction is 0.3 , to the negative x-direction is 0.2 , to the positive y-direction is 0.2 and to the negative y-direction is 0.3 . If a particle starts from the origin, its mean position after N steps is

1. $\frac{1}{10}N(-\hat{i}+\hat{j})$
2. $\frac{1}{10}N(\hat{i}-\hat{j})$
3. $N(0.3\hat{i}-0.2\hat{j})$
4. $N(0.2\hat{i}-0.3\hat{j})$

Q8. [June 2019] . 5.0 marks

Statistical Mechanics > Random Walk/Brownian motion/Diffusion

CSIR NET	2019 June	5M

At each time step, a random walker in one dimension either remains at the same point with probability $\frac{1}{4}$, or moves by a distance Δ to the right or left with probabilities $\frac{3}{8}$ each. After N time steps, its root mean squared displacement is

1. $\Delta\sqrt{N}$
2. $\Delta\sqrt{\frac{9N}{16}}$
3. $\Delta\sqrt{\frac{3N}{4}}$
4. $\Delta\sqrt{\frac{3N}{8}}$

Q9. [June 2021] . 3.5 marks

Statistical Mechanics > Random Walk/Brownian motion/Diffusion

CSIR NET	2021 June	3.5M

The position of a particle in one dimension changes in discrete steps. With each step it moves to the right, however, the length of the step is drawn from a uniform distribution from the interval $\left[\lambda - \frac{1}{2}w, \lambda + \frac{1}{2}w\right]$, where λ and w are positive constants. If X denotes the distance from the starting point after N steps, the standard deviation $\sqrt{\langle X^2 \rangle - \langle X \rangle^2}$ for large values of N is

1. $\frac{\lambda}{2} \times \sqrt{N}$
2. $\frac{\lambda}{2} \times \sqrt{\frac{N}{3}}$
3. $\frac{w}{2} \times \sqrt{N}$
4. $\frac{w}{2} \times \sqrt{\frac{N}{3}}$

Q10. [June 2022] . 3.5 marks

Statistical Mechanics > Random Walk/Brownian motion/Diffusion

CSIR NET	2022 June	3.5M

A walker takes steps, each of length L, randomly in the directions along east, west, north and south. After four steps its distance from the starting point is d. The probability that $d \leq 3L$ is

1. $63/64$
2. $59/64$
3. $57/64$
4. $55/64$

Q11. [Dec 2023] . 5.0 marks

Statistical Mechanics > Random Walk/Brownian motion/Diffusion

CSIR NET	2023 Dec	5 M

A photon inside the sun executes a random walk process. Given the radius of the sun $\approx 7 \times 10^8$ km and mean free path of a photon $\approx 10^{-3}$ m, the time taken by the photon to travel from the centre to the surface of the sun is closest to

1. 10^6sec
2. 10^{24}sec
3. 10^{12}sec
4. 10^{18}sec

Q12. [June 2023] . 5.0 marks

Statistical Mechanics > Random Walk/Brownian motion/Diffusion

CSIR NET	2023 June	5M

Two random walkers A and B walk on a one-dimensional lattice. The length of each step taken by A is one, while the same for B is two, however, both move towards right or left with equal probability. If they start at the same point, the probability that they meet after 4 steps, is

1. 9/64
2. 5/32
3. 11/64
4. 3/16

Q13. [June 2024] . 5.0 marks

Statistical Mechanics > Random Walk/Brownian motion/Diffusion

CSIR NET	2024 June	5M

A random walker takes a step of unit length towards right or left at any discrete time step. Starting from $x = 0$ at time $t = 0$, it goes right to reach $x = 1$ at $t = 1$. Hereafter if it repeats the direction taken in the previous step with probability p, the probability that it is again at $x = 1$ at $t = 3$ is

1. $1 - p$
2. $(1 - p)^2$
3. $2p(1 - p)$
4. $4p^2(1 - p)$

Q14. [Dec 2025] . 3.5 marks

Statistical Mechanics > Random Walk/Brownian motion/Diffusion

CSIR NET	2025 Dec	3.5M	Stat. Mech.

A 1-dimensional random walker's displacement is always positive and is equally likely to be anywhere in the range $[L, L+b]$. After N statistically independent steps the mean distance covered by the walker is

1. NL
2. $N\sqrt{L^2+b^2}$
3. $N\left(L+\frac{b}{2}\right)$
4. $NL+b\sqrt{N}$

Q15. [June 2025] . 5.0 marks

Statistical Mechanics > Random Walk/Brownian motion/Diffusion

CSIR NET	2025 June	5M	Stat. Mech.

Two discrete time random walkers start from the point $x = 0$ at time $t = 0$ taking discrete steps of unit length along the x axis. The first walker is unbiased and the second walker is biased to move towards the right with probability p. The probability that they are at a distance of 2 units from each other at both time steps $t = 1$ and $t = 2$ is

1. $\frac{1}{4}$
2. $\frac{1}{2} - \frac{p}{2}$
3. $1 - \frac{3p}{4}$
4. $\frac{p}{2}$

Answer Key

15 questions . Subject and topic for quick revision

Q. No	Subject	Topic	Answer
Q1	Statistical Mechanics	Random Walk/Brownian motion/Diffusion	**4**
Q2	Statistical Mechanics	Random Walk/Brownian motion/Diffusion	**None**
Q3	Statistical Mechanics	Random Walk/Brownian motion/Diffusion	**4**
Q4	Statistical Mechanics	Random Walk/Brownian motion/Diffusion	**3**
Q5	Statistical Mechanics	Random Walk/Brownian motion/Diffusion	**3**
Q6	Statistical Mechanics	Random Walk/Brownian motion/Diffusion	**1 or 3**
Q7	Statistical Mechanics	Random Walk/Brownian motion/Diffusion	**2**
Q8	Statistical Mechanics	Random Walk/Brownian motion/Diffusion	**3**
Q9	Statistical Mechanics	Random Walk/Brownian motion/Diffusion	**4**
Q10	Statistical Mechanics	Random Walk/Brownian motion/Diffusion	**4**
Q11	Statistical Mechanics	Random Walk/Brownian motion/Diffusion	**4**
Q12	Statistical Mechanics	Random Walk/Brownian motion/Diffusion	**3**
Q13	Statistical Mechanics	Random Walk/Brownian motion/Diffusion	**1**
Q14	Statistical Mechanics	Random Walk/Brownian motion/Diffusion	**3**
Q15	Statistical Mechanics	Random Walk/Brownian motion/Diffusion	**1**