TOYS & TEA

TEA AND COOKIES SERVED

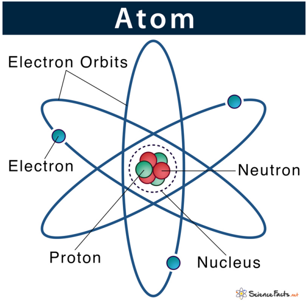
EVERY OTHER THURSDAY

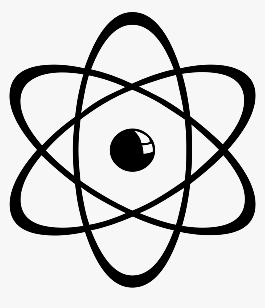
4:00 - 5:00 PM

PHYSICS STUDENT LOUNGE
OLIN 251A

COME AND EXPERIENCE FUN EXPERIMENTS WITH YOUR FAVORITE PHYSICS & ASTRONOMY FACULTY

Common picture of an atom:





This kind of atom could not exist! The accelerating electron would radiate away all of its energy as an EM wave, and then crash into the nucleus.

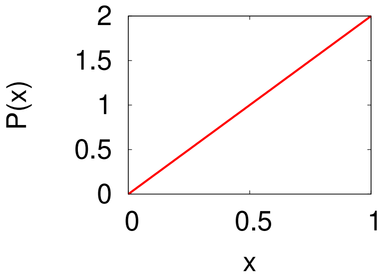
Classical mechanics + E&M $\Rightarrow$ atoms can't exist!!

. . . but fortunately atoms **do** exist. We have to give up on classical mechanics to explain them.

Lecture 15 — Concept Test 1

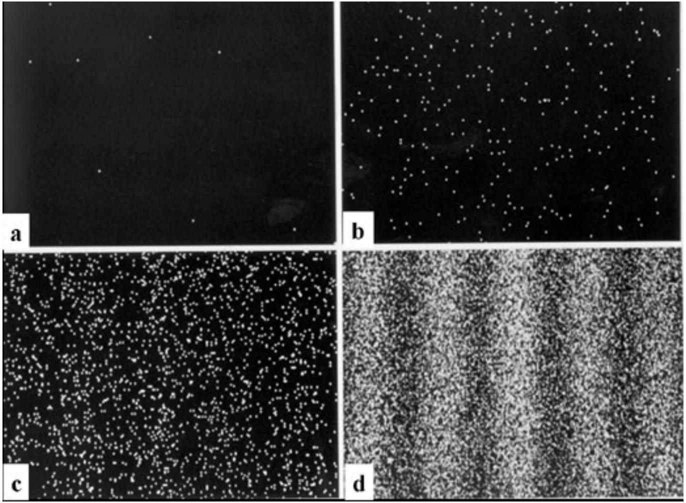
A particle is associated with a probability density $P(x) = 2x$ from $x = 0$ to $x = 1$, and $P(x) = 0$ for all other values of x.

What is the probability that the particle would be found between $x = 0$ and $x = 1/2$?



1. 0
2. $1/8$
3. $1/4$
4. $1/2$
5. 1
6. 2

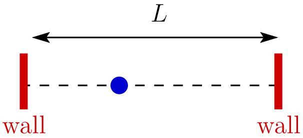
Electron Double Slit Experiment



https://www.hitachi.com/rd/research/materials/quantum/doubleslit/index.html

Lecture 15 — Concept Test 2

You trap a particle in a very small 1D box such that the spread in position σ_x must be quite small. What does Heisenberg's Uncertainty Principle imply about this particle?



Answer each statement with **1 = True** or **2 = False**.

A. A spread in position $\sigma_x < L$ implies a spread in momentum σ_{p_x} (and therefore velocity) greater than zero.

B. There is a minimum kinetic energy greater than zero that the particle must have.

C. If we make the box smaller, the kinetic energy of the particle becomes smaller

Lecture 15 — Concept Test 3

Given the equation $\dfrac{df(x)}{dx} + 6x - 2 = 0$, test the trial solution

$$f(x) = Ax + B$$

to see if it works. If so, determine the values of the constants A and B needed to make it work.

1. This doesn't work for all values of x.
2. Works if $A = 6$ and $B = -2$
3. Works if $A = -6$ and $B = 2$.
4. Works if $A = 2$ and $B = -6$
5. Works if $A = -2$ and $B = 6$
6. Works if $A = \pi$ and $B = \sqrt{17}$.

Lecture 15 — Concept Test 4

Given the equation $\frac{df(x)}{dx} + 6x - 2 = 0$, test the trial solution

$$f(x) = Ax^2 + Bx + C$$

to see if it works. If so, determine the values of the constants A, B, and C needed to make it work.

1. This doesn't work for all values of x.
2. Works if $A = 6$, $B = -2$, and $C = 0$
3. Works if $A = -6$, $B = 2$, and C can be anything
4. Works if $A = 3$, $B = -2$, and $C = 0$
5. Works if $A = -3$, $B = 2$, and C can be anything
6. Works if $A = \pi$, $B = \sqrt{17}$, and $C = \sqrt{-1}$.

Schrödinger Equation for $U = 0$: $$-\frac{\hbar^2}{2m}\frac{d^2\psi}{dx^2} + 0 = E\,\psi(x)$$

Try $\psi(x) = A\sin(kx)$. ✓

- Derivatives: (1) $\dfrac{d\psi}{dx} = Ak\cos(kx)$ and (2) $\dfrac{d^2\psi}{dx^2} = -Ak^2\sin(kx)$.
- Now plug into Schrödinger's equation: $-\dfrac{\hbar^2}{2m}\left[-Ak^2\sin(kx)\right] \stackrel{?}{=} E\left[A\sin(kx)\right]$
- It is a solution for all x as long as $E = \dfrac{\hbar^2 k^2}{2m}$. ✓

Compare to the de Broglie relation:

$$p = \frac{h}{\lambda} = \left(\frac{h}{2\pi}\right)\left(\frac{2\pi}{\lambda}\right) = \hbar k \quad \Rightarrow \quad E = K + U = \frac{p^2}{2m} + 0 = \frac{\hbar^2 k^2}{2m}. \quad ✓$$