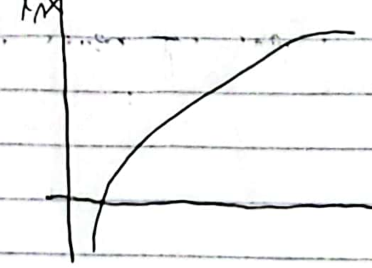
Lecture 4

Jan 25, 2023

last time: Math concepts

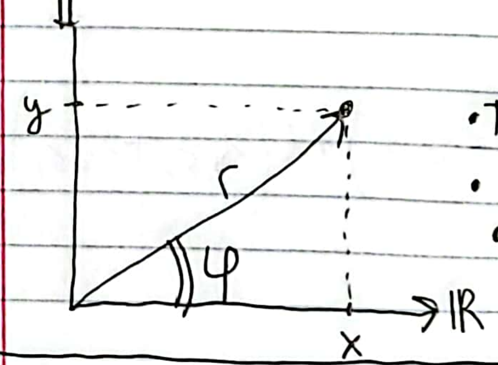
(5) $\ln x$



- monotonic (unique inverse e^x)
- $\ln(a \cdot b) = \ln a + \ln b$ additive : extensive
- makes big numbers small

ex. $W_1 \cdot W_2 \xrightarrow[\ln W]{S=} S_1 + S_2$; $\frac{W_1}{W_2} \rightarrow S_1 - S_2 = \Delta S$

(6) Complex numbers: $z = x + iy = re^{i\varphi}$ $\begin{cases} r = \sqrt{x^2+y^2} \\ \tan\varphi = y/x \end{cases}$



- They "complete the numbers"
- $i = \sqrt{-1} = e^{i\pi/2}$ so $r = 1$, $\varphi = \frac{\pi}{2} = 90°$
- $e^{i\varphi} = \cos\varphi + i\sin\varphi$

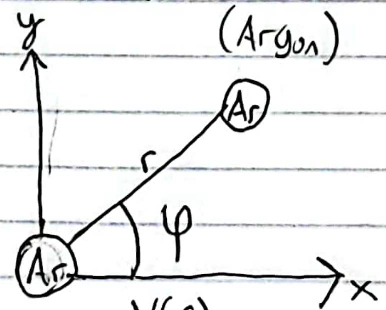
Today: Why go quantum? (QM = quantum mechanics)
(CM = Classical mechanics)

In CM, $E = \sum_i \frac{p_i^2}{2m_i} + V(x_i)$ ($i \rightarrow$ labels particles)

$p_i = m_i v_i$ — kinetic E, Potential E

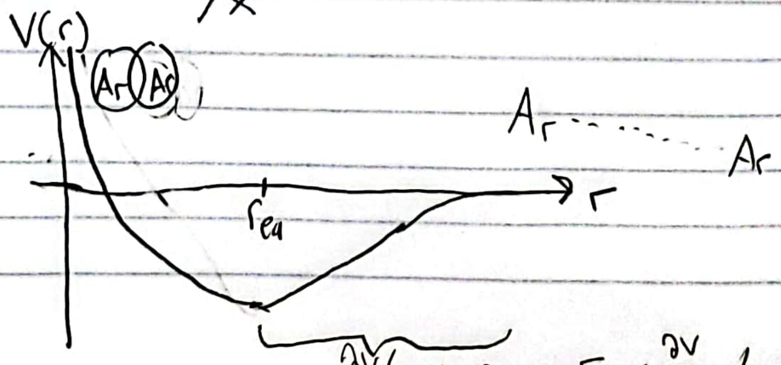
$F_i = -\frac{\partial V}{\partial x_i}$

ex:



How does potential energy relate to r, φ

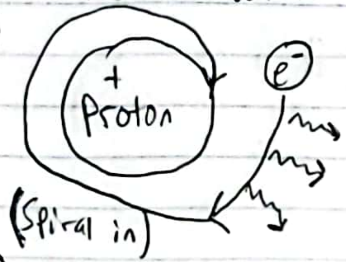
$V(r,\varphi) \overset{?}{=} V(r)$ no φ dependence



If $r > r_{eq}$, atoms attract
If $r < r_{eq}$, atoms repel

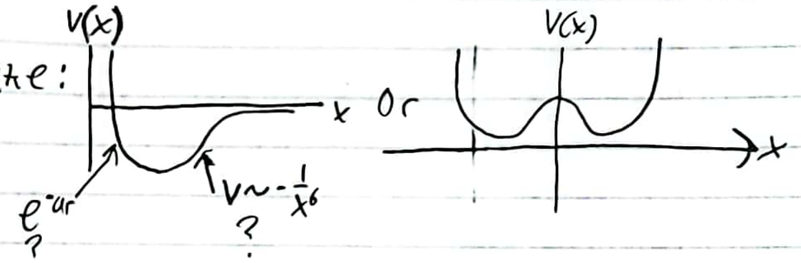
$\partial V/\partial r > 0 \Rightarrow F = -\frac{\partial V}{\partial r} < 0$

The Problems with CM:

① 

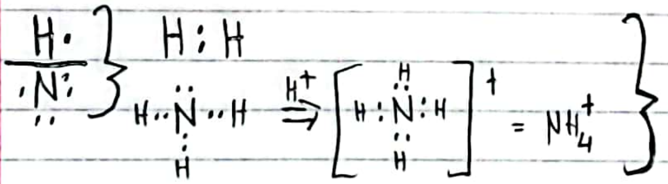
for earth + Sun ⇒ billions of years to spiral in
for $p^+ + e^-$ ⇒ < 1 femto second !! huge discrepancy

② How to get Potentials like:



need QM to get V(x)

Early 1900s : G.N. Lewis



e^- get Paired
Why? Answer: spin!

1925 W. Heisenberg = in nature, there are 2 kinds of variables
1) a and b are independent ⇒ $\Delta a \cdot \Delta b = 0$ } Can have precise values at same time
2) a and b are conjugate ⇒ $\Delta a \cdot \Delta b > 0$ } cannot have precise values at same time

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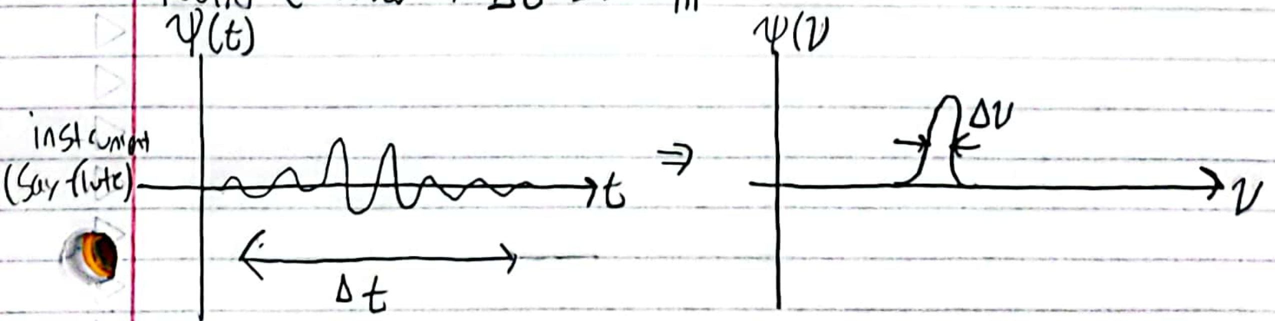
ex: Music Δa = duration of sound = Δt ; $t = a$
Δb = spread of the frequency = $\Delta \nu$; $\nu = b$
Fourier (~1780) ⇒ $\Delta t \cdot \Delta \nu = \frac{1}{4\pi}$



drums: