IN DIFF EQN LANGUAGE

TDSE $\longrightarrow$ TISE

COMES FROM SEPARATING VARIABLES

$$\frac{-\hbar^2}{2m}\frac{d^2\psi}{dx^2} + V(x)\,\psi(x,t) = i\hbar\frac{d}{dt}\psi(x,t)$$

$$\psi(x,t) = f(x)\,g(t)$$

$$\frac{-\hbar^2}{2m}\frac{d^2}{dx^2}(f\cdot g) + V(x)(f\cdot g) = i\hbar\frac{d}{dt}(f\cdot g)$$

$$g\left(-\frac{\hbar^2}{2m}\right)\frac{d^2f}{dx^2} + g\,V(x)\,f = f\,(i\hbar)\frac{dg}{dt}$$

$$\frac{1}{f\cdot g}$$

$$\frac{\frac{-\hbar^2}{2m}\frac{d^2f}{dx^2}}{f} + \frac{V(x)\,f}{f} = \frac{(i\hbar)\frac{dg}{dt}}{g} = E_n$$

$$\frac{dg}{dt} = \frac{E_n}{i\hbar}\,g = -\frac{iE_n}{\hbar}\,g$$

$$g(t) = e^{-iE_nt/\hbar}$$

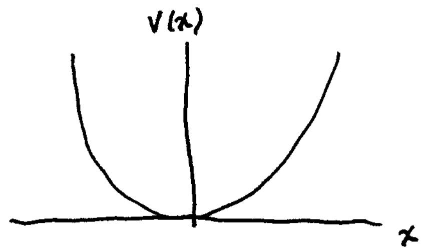
LEFT WITH TISE

$$H\,|\psi_n\rangle = E_n\,|\psi_n\rangle$$

$$\left[-\frac{\hbar^2}{2m}\frac{d^2}{dx^2}+V(x)\right]\psi_n(x)=E_n\,\psi_n(x)$$

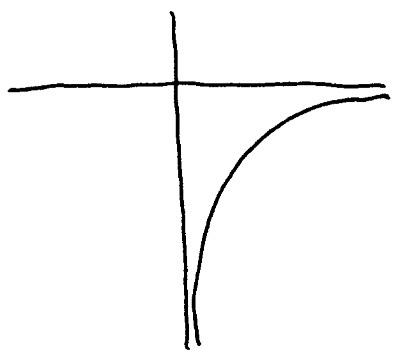
in 3d ∇^2

different $V(x)$'s



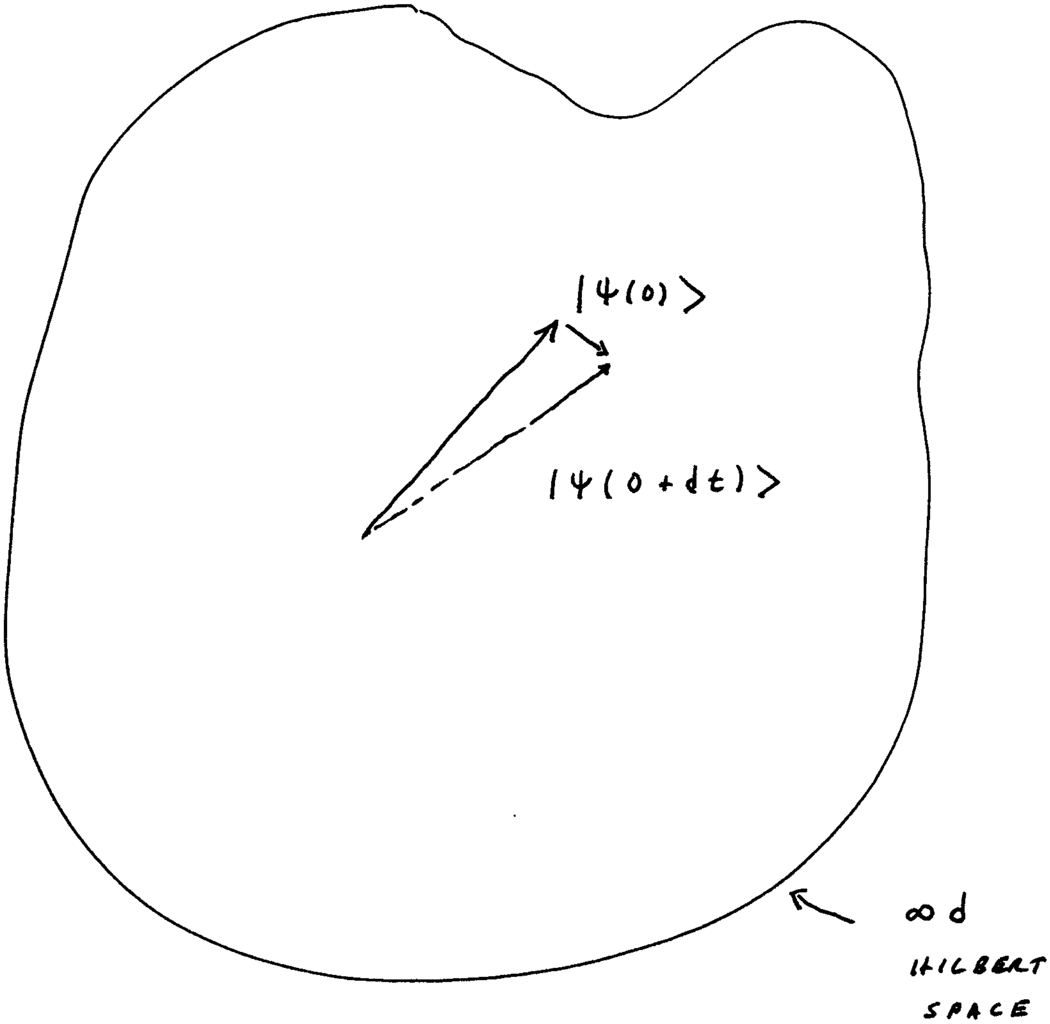
SHO

$V(x)\sim x^2$



$V(r)\sim \frac{1}{r}$

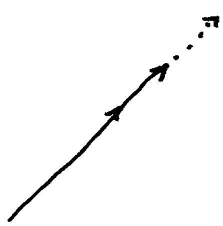
GEOMETRY



TDSE $\quad H|\psi\rangle = i\hbar \dfrac{d}{dt}|\psi\rangle$

$$d|\psi\rangle = \frac{1}{i\hbar} H|\psi\rangle\, dt$$

TISE $\quad H|\psi\rangle = E|\psi\rangle$



H just changes the length of its
eigen vectors
eigen fcns
~~and~~ phase comes from $|\psi_n(t)\rangle = e^{-iE_n t/\hbar}\,|\psi_n(0)\rangle$

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Physics 324
Quantum Mechanics 1

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Course Description

An introduction to non-relativistic quantum mechanics. Topics will include: the mathematics of quantum mechanics, bra and ket notation, the postulates of quantum mechanics, one-dimensional problems, the harmonic oscillator, angular momentum, the hydrogen atom, and non-relativistic path integrals.

Download Course Information Packet
Download Exam 1
Download Exam 2

Homework Assignments

Homework Assignment 1
Chapter 1.1: 26, 27, 29, 33, 34, 36
Chapter 1.2: 27, 30, 32
Correction for 1.1.26b: -10+4i should be -10-4i
Correction for 1.2.27a: det(A)=4 should be det(A)=1
Homework Set 1 Solutions
Homework Set 1b Solutions

Homework Assignment 2
Chapter 1.2: 33, 34, 38, 39, 40
Chapter 1.3: 30, 32, 39, 40
Homework Set 2 Solutions
Homework Set 2b Solutions

Homework Assignment 3
Chapter 2: 33, 34, 36, 38, 41, 42
Homework Set 3.1 Solutions..... .....Homework Set 3.2 Solutions

Homework Assignment 4
Chapter 3: 37, then rework 37 using wavefcn in 31
Chapter 4: 10, 13
Chapter 5: 30, 31, 33
Chapter 3 Solutions .....Chapter 4 Solutions..... Chapter 5 Solutions

Homework Assignment 5
Chapter 8: 40, 41, 42, 43, 45, 46
Homework Set 5 Solutions .....HW Set 5 Figures

Homework Assignment 6
Homework Assignment 6 .....Homework 6 Hints
Homework Set 6 Solutions .....HW 6 Figures

Homework Assignment 7
Homework Assignment 7 .....Homework 7 Hints .....More HW 7 Help!!!
Homework Set 7 Solutions

Virtual Book

Chapter 1.1 .....Chapter 1.2 .....Chapter 1.3

Chapter 2.1 .....Chapter 2.2

Chapter 3.1 .....Chapter 3.2

Chapter 4

Chapter 5.1 .....Chapter 5.2

Chapter 6

Chapter 7

Chapter 8.1 .....Chapter 8.2 .....Chapter 8.3 .....About the SHO operators

Chapter 9.1 .....Chapter 9.2 .....Chapter 9 Figures

Chapter 10.1 .....Chapter 10.2 .....Chapter 10 Figures

Reading

The Mathematics
The Postulates

What's the difference between a Hilbert space and a finite-dimensional vector space?

Lecture 1: Nine Formulations of Quantum Mechanics
Lecture 1: Is the moon there when nobody looks?

Lectures

Lecture 1
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Feynman

The Quantum Mechanical View of Nature

QED 1
QED 2
QED 3
QED 4
QED 5

QED Videos
QED Simulations

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LECTURE 18 7-23-09

ANALOGY LINEAR ALGEBRA FINITE DIM VECTOR SPACE

FUNCTIONAL ANALYSIS ∞ DIM HILBERT SPACE

$\vec{v}$ = COLLECTION OF n NUMBERS

$f(x)$ = COLLECTION OF NUMBERS, ONE FOR EVERY POINT ON LINE

INNER PRODUCT: GENERALIZATION OF DOT PRODUCT FOR $\mathbb{C}$

$$\vec{v} = \sum a_j \hat{e}_j$$

$$\vec{w} = \sum b_j \hat{e}_j$$

$$\vec{v} \cdot \vec{w} = \sum_i a_i b_i \quad \text{FOR REAL NUMBERS}$$

$$\vec{v} \cdot \vec{w} = \sum_i v_i^* w_i$$

$$\vec{w} \cdot \vec{v} = \sum_i w_i^* v_i \underset{\text{general}}{\neq} \vec{v} \cdot \vec{w}$$

$$\langle v | w \rangle = \langle w | v \rangle^*$$

$$|v| = \sqrt{\vec{v} \cdot \vec{v}}$$ OKAY FOR REAL VALUED

NOT OKAY FOR COMPLEX VALUED

$$\sum_i v_i^* v_i$$ IS REAL

ANALOGY

$$\langle x | v \rangle = v(x)$$

$$\langle x | w \rangle = w(x)$$

$$\langle w | v \rangle = \int w(x)^* \, v(x) \, dx \qquad\qquad \sum_i w_i^* v_i$$

$$\langle \psi | \psi \rangle = \int \psi^*(x) \, \psi(x) \, dx = |\psi|^2$$

FINDING COMPONENTS

$$\vec{v} = \sum a_i \hat{e}_i$$

TO FIND a_j

$$\hat{e}_j \cdot \vec{v} = a_j$$

$|v\rangle$ FIND "a_j"

$$\langle E_j | v \rangle = a_j = \int E_j^*(x) \, V(x) \, dx$$

$$= \int \sqrt{\frac{2}{a}} \sin(k_j x) \; V(x) \, dx$$

$$\Rightarrow V(x) = \sum_j a_j \sqrt{\frac{2}{a}} \sin(k_j x)$$

$$|\psi(t=0)\rangle = \frac{1}{\sqrt{2}}|E_1\rangle + \frac{1}{\sqrt{2}}|E_2\rangle$$

in position space $\langle x|$

$$\langle x|\psi(t=0)\rangle = \frac{1}{\sqrt{2}}\langle x|E_1\rangle + \frac{1}{\sqrt{2}}\langle x|E_2\rangle$$

$$\psi(x,0) = \frac{1}{\sqrt{2}}\psi_1(x) + \frac{1}{\sqrt{2}}\psi_2(x)$$

EXPANSION IN ENERGY EIGENFCNS

SOLN TO TISE

TDSE

$$\psi(x,t) = \frac{1}{\sqrt{2}}\psi_1(x)\,e^{-iE_1t/\hbar} + \frac{1}{\sqrt{2}}\psi_2(x)\,e^{-iE_2t/\hbar}$$

$$= \frac{1}{\sqrt{2}}\sqrt{\frac{2}{a}}\sin\left(\frac{\pi}{a}x\right)e^{-iE_1t/\hbar} + \frac{1}{\sqrt{2}}\sqrt{\frac{2}{a}}\sin\left(\frac{2\pi}{a}x\right)e^{-iE_2t/\hbar}$$

$$E_n = \frac{\hbar^2k^2}{2m} = \frac{\hbar^2}{2m}\left(\frac{n\pi}{a}\right)^2 \Rightarrow E_1 = \frac{\hbar^2}{2m}\left(\frac{\pi}{a}\right)^2$$

$$E_2 = \frac{\hbar^2}{2m}\left(\frac{2\pi}{a}\right)^2$$