Group HW For Friday (11/3)
Q 12 R.1
Q 13 R.1
Q 13 D.6

Daily HW: (#23)
"Practice" "quiz" handout

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PHY 232-01
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(Schrodinger Equation)

Modern Physics Notes 10/27

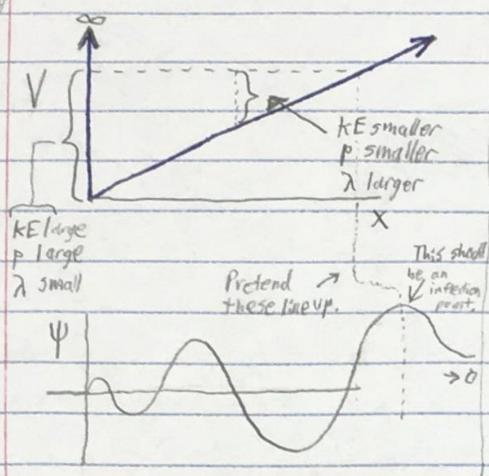
$\lambda = \frac{h}{p}$ → Suppose fixed total energy E
De Broglie

P.E. varies with position $V(x)$

K.E. varies with position $K(x) = E - V(x)$ $\qquad E - V(x) = K(x) = \frac{h^2}{2m\lambda^2(x)}$

$= \frac{p^2}{2m} = \frac{1}{2}mv^2$

"What I'm doing to you now is lying, but in a helpful way."



$\Psi(x,t)$

$i\hbar \frac{\partial \Psi(x,t)}{\partial t} = -\frac{\hbar^2}{2m}\frac{\partial^2 \Psi(x,t)}{\partial x^2} + V(x)\Psi(x,t)$

valid for any legit matter wave

$\Psi(x,t) = \psi(x)\,\Phi(t)$

$-\frac{\hbar^2}{2m}\frac{d^2\psi_E(x)}{dx^2} + V(x)\psi_E(x) = E\,\psi_E(x)$

This equation's solutions give
- energy e-values
- energy e-functions

"Derivation & chill?"
"Yah."

Approaches
- ① Analytical
- ② Numerical (e.g. lab)
- ③ Qualitative

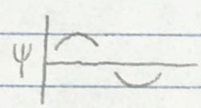
$$\boxed{\frac{d^2\psi_E(x)}{dx^2} = -\left\{\frac{2m[E - V(x)]}{\hbar^2}\right\}\psi_E(x)}$$

"I think the way that quantum physics developed was kind of pillow talk."

Characteristics of a legit matter wave
1. $\psi(x)$ continuous
2. $\psi \to 0$ as $x \to \pm\infty$
3. $\frac{d\psi}{dx}$ continuous except where $V = \infty$ ("∞ bad")

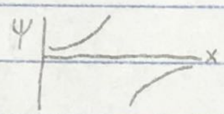
Eigenfunction behavior

④ If $E - V(x) > 0$ →



Oscillatory → Classically allowed region

⑤ If $E - V(x) < 0$ →



Exponential → Classically forbidden region

⑥ Where $E - V(x) = 0$ → Inflection point → Classical Turn Around

continued

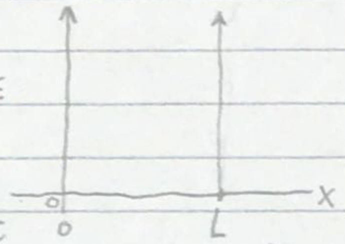
"ψ's doesn't matter."

(Analytically)

Another way of solving the Schrodinger Eq. (w/ Diff. eq.)

$$\frac{d^2\psi}{dx^2} = \frac{2mE}{\hbar^2}\psi = -k^2\psi$$

DE



$\psi(0) = \psi(L) = 0$

$\psi(x)\ A\sin(kx) + B\cos(kx)$

$\psi(0)\ A\sin(0) + B\cos(0) = B = 0$ BC

$\psi(L)\ A\sin(\underbrace{kL}_{n\pi}) = 0 \quad \boxed{k_n = \frac{n\pi}{L}} \quad (0 < x < L)$

$E_n =$ ___ ... (Board erased.)

$$\psi_n(x) = \begin{cases} A\sin\left(\frac{n\pi x}{L}\right) & 0 < x < L \\ 0 \end{cases}$$

NAME ____________________

INSTRUCTIONS: This is a closed-book, closed-notes, no-calculator quiz whose purpose is to explore your understanding of the basic *concepts* presented so far in the class. Please do any work on this sheet of paper, using the back of the paper only if necessary (there are some *simple* calculations required on this quiz, but you should be able to do them in your head). This quiz is worth 20 points: pace yourself at about 1 point per minute. You may write *optional* comments in the space below each question; any comments that you write will be considered (for better or worse) into your grade.

1. The vibrational energy levels of a certain diatomic molecule are given by $E_n = \hbar\omega(n+\frac{1}{2})$, where n is an integer and $\hbar\omega = 0.124$ eV. (Note that $hc = 1240$ eV·nm.)

   a. (1 pt) What is the energy of the longest-wavelength photon that can be emitted by transitions between vibrational states of this molecule? Fill in the blank.

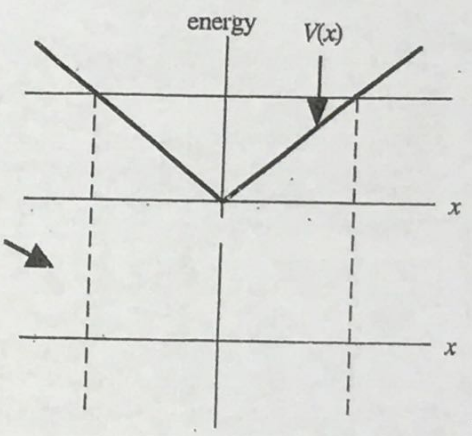
   E_{ph} = ________ eV

   b. (2 pts) What would the wavelength of this photon be? Fill in the blank and check the appropriate box. (If you aren't sure of your answer for *a*, assume that $E_{ph} = 0.124$ eV.)

   = ________ nm   which is in the   ☐ visible   ☐ infrared   ☐ ultraviolet

2. (4 pts) **Draw** the third energy eigenfunction for a quanton whose potential energy function is $V(x) = a|x|$ (where a is some constant) as shown to the right (this potential energy function has been proposed as describing the interaction between two quarks). Also, **indicate** the locations where you are *most* likely and *least* likely to find the quanton. Feel free to add words to clarify your picture if necessary.

   Draw your eigenfunction on this graph



3. (3 pts) We saw in class that we can fairly accurately model certain organic dye molecules as if they contained N electrons trapped in a "box"-like potential energy function, where N is some even integer. The energy of a single quanton in a box is given by $E_n = E_1 n^2$, where n is an integer and E_1 is the energy of the ground ($n = 1$) energy level. If for a given molecule, there are 4 electrons trapped in the molecule's "box," what is the lowest possible *total* energy of these electrons? (Express your answer as a multiple of E_1).

4. (3 pts) Imagine that we have a wave machine 1.2 m long that is fixed at both ends. If the velocity of waves on the wave machine is 2.4 m/s, what is the frequency of the normal mode of the wave machine's oscillation that has one antinode? (*Hint:* You don't really need to know any formulas to do this problem: just think about what is going on physically. Showing some work or giving an argument may earn you some partial credit even if you are wrong.)

5. (2 pts) Light with a wavelength goes through a narrow slit. The angle between the first diffraction minimum on one side of the central maximum and the first minimum on the other side is θ. If the wavelength of the light is halved, how does θ change?

- ☐ increases by a factor of 2
- ☐ remains the same
- ☐ decreases by a factor of 2
- ☐ other (specify)

6. (2 pts) When light from an ultraviolet light source strikes a metal surface, a stream of electrons emerges from the metal. If the intensity of the light striking the surface is doubled,

- ☐ more electons are emitted in a given time interval
- ☐ the electrons that are emitted are more energetic
- ☐ both of the above
- ☐ neither of the above

7. (3 pts) Imagine that a quanton has the wavefunction shown below. If it an experiment is performed that localizes the quanton, what is the probability that it will be found to have position X such that 1 nm $< X <$ 2 nm? (Again, showing your work may earn you some partial credit if your answer is wrong.)