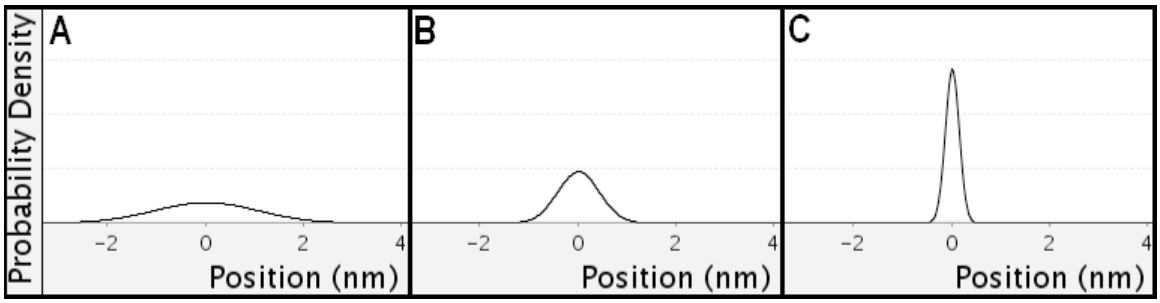
PHYS 225: Applications of Modern Physics **Marie Lopez del Puerto**

HW #14

1. We've been using a bunch of new terms and symbols, including:
   a. ψ
   b. $|\psi|^2$,
   c. $\psi^*\psi$,
   d. "the wave function", and
   e. "the probability density".

Explain the relationship between these terms and symbols. Which could you infer from the intensity of electrons hitting a screen?

2. Below are 3 plots of $|\psi(x)|^2$, the probability density, for 3 free electrons:



i. Which has the greatest uncertainty in position?

ii. If you define uncertainty in position for a distribution like this as the distance between the points at which the probability density has dropped to ½ its max value, then what is the approximate uncertainty in position for graph B (in nm)?

iii. A plane wave has: (check all that apply)
   large uncertainty in position
   small uncertainty in position
   large uncertainty in momentum
   small uncertainty in momentum

iv. Relative to a plane wave, a wave packet has: (check all that apply)
   larger uncertainty in position
   smaller uncertainty in position
   larger uncertainty in momentum
   smaller uncertainty in momentum

3. In class we found that, for the infinite potential well, $\psi(x) = 2iA\sin(kx)$ for $0<x<L$. Show that the normalization constant A is given by $A = (2L)^{-1/2}$.

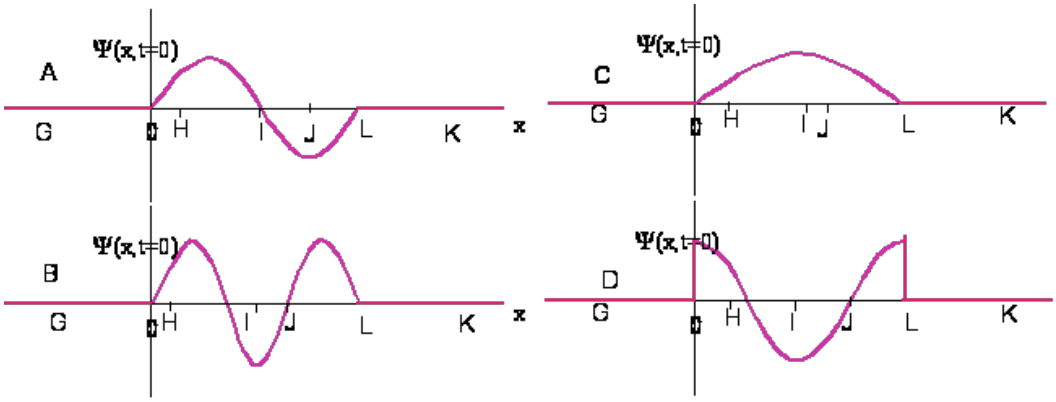
4. An electron wave function between 0 and L is described by the following function:

$\psi(x,t) = (2/L)^{1/2}\sin(2\pi x/L)e^{-i\omega t}$, $0 < x < L$

$\psi(x,t) = 0$ for $x<0$ and $x>L$

which is the n = 2 solution for the infinite well.

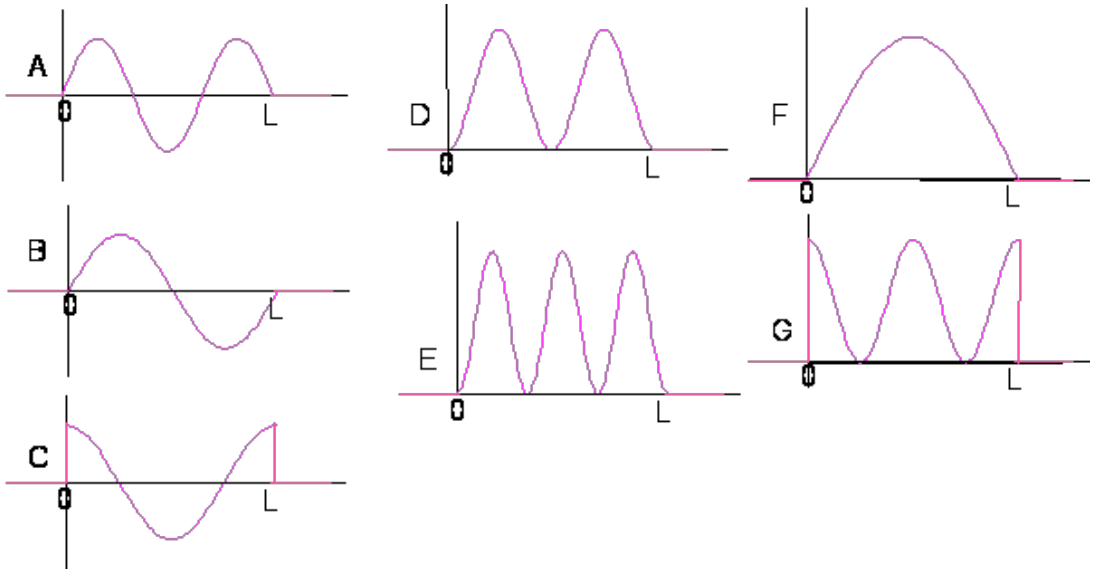
i. What does this wave look like at t=0?



ii. Which of the following interpretations of this wave function are valid:

True False The electron's position is higher at G than at J
True False The electron moves up and down as it travels between 0 and L
True False The wave function (and associated probability density) as a function of position between 0 and L does not change as time passes
True False The probability of finding the electron at L/2 is 0
True False The probability of finding the electron between 0 and L/2 is 1/2

iii. What does the probability density, $P(x) = |\psi(x,t)|^2$, look like for this wave function?



iv. At t=0, how do the probabilities of finding the electron very close (within a very small distance dx) to x=G, H, I, J, and K compare? Where P(G)=Probability of finding the electron near point G:

a. P(G) = P(H) = P(I) = P(J) = P(K)
b. P(H) > P(J) = P(G) = P(K) > P(I)
c. P(H) > P(I) = P(G) = P(K) > P(J)
d. P(J) > P(H) > P(I) = P(G) = P(K)
e. P(H) > P(I) > P(J) > P(G) = P(K)
f. P(I) > P(J) > P(H) > P(G) = P(K)
g. P(I) > P(H) > P(J) > P(G) = P(K)

v. What is the total probability of detecting this electron between L/4 and 3L/4?

vi. If you had a bunch of electrons all with this same wave function and detected where the electrons were on a fluorescent screen, what pattern would you expect to see: