

Name: \_\_\_\_\_

1) The wave function for a particle is sketched below. Assume  $\Delta x \ll a$ .

(a) What is  $\langle \hat{X} \rangle$ ?

(b) List possible values of position that can be measured and their probability.

2) A particle in a box,  $0 < x < L$ , is in the state:

$$\psi(x) = 2\phi_2(x) + 4\phi_4(x) - \phi_5(x).$$

(a) What is the lowest energy that can be measured? Assume mass  $m$  and give the answer in terms of  $m$  and other constants. Define any constants you use.

(b) What is  $\langle \hat{X} \rangle$ ? Give an answer correct at any time  $t$ .

- 3) Assume  $\hat{H}|\phi_n\rangle = E_n|\phi_n\rangle$ . At  $t = 0$ ,  $|\psi\rangle = \frac{1}{\sqrt{5}}|\phi_1\rangle + \frac{2}{\sqrt{5}}|\phi_3\rangle$ .
- (a) What is the probability to find the particle with  $0 < x < L$  at time  $t = \pi/E_1$ . Use  $\langle x|\phi_n\rangle = \phi_n(x)$ .

- (b) The particle is measured to have energy  $E_3$ . What is the probability to find  $0 < x < L$  at a time  $t = \pi/E_1$  later?

4) For a free particle,  $\hat{H} = \frac{\hat{P}^2}{2m}$ . At  $t = 0$ ,  $\psi(x) = A \sin(\frac{2\pi x}{L})$  for  $-L < x < L$ ,  
 $\psi(x) = 0$  for  $|x| > L$ .  
(a) What is  $\psi(x, t)$ ?

(b) What are  $\langle \hat{P} \rangle$  and  $\langle \hat{H} \rangle$ ?

5) (extra credit) For a box  $0 < x < a$ ,  $\psi(x) = \phi_5(x)$  for  $0 < x < a/2$  and  $\psi(x) = 0$  for  $a/2 < x < a$ . Find  $\langle \hat{X} \rangle (t)$  and discuss the velocity of motion. Describe what you would 'see' as time progresses.