5.73

Quiz 12

1.
> The matrices for x and p, evaluated in the harmonic oscillator eigenbasis, have the general nonzero matrix elements:
>
> $$\langle n | x | n+1 \rangle = x_{n,n+1} = \left[\frac{\hbar}{2\omega\mu} \right]^{1/2} (n+1)^{1/2}$$
>
> $$p_{n,n+1} = -i \left[\frac{\hbar\omega\mu}{2} \right]^{1/2} (n+1)^{1/2}$$

A. x and p are Hermitian. Write the "other" nonzero matrix element (be careful about p!)
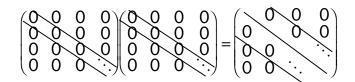
$x_{n+1,n} =$

$p_{n+1,n} =$

B.   What are the general "selection rules" for nonzero matrix elements of x, p, and x^2?

For x, $\Delta n = ?$

For p, $\Delta n = ?$

For x^2, $\Delta n = ?$ and $?$

C. If you multiply x times x, the matrix multiplication cartoon helps:

$$
\begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \ddots \end{pmatrix}
\begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \ddots \end{pmatrix}
=
\begin{pmatrix} & 0 & 0 & 0 \\ 0 & & 0 & 0 \\ 0 & 0 & & \ddots \\ 0 & 0 & & \ddots \end{pmatrix}
$$

Based on the cartoon, what is the general selection rule for nonzero matrix elements of x^k?