UNIVERSITY OF CALIFORNIA, SANTA BARBARA
Department of Physics

Physics 115A — Winter 1996
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FINAL EXAM

Information (con't.)

$\hat{X} = \beta X, \qquad \hat{P} = \frac{P}{\hbar\beta} \qquad \beta = \sqrt{\frac{m\omega}{\hbar}}$

$[\hat{X}, \hat{P}] = i \qquad H = \hbar\omega\hat{H} \qquad \hat{H} = \frac{1}{2}(\hat{X}^2 + \hat{P}^2)$

$a = \frac{1}{\sqrt{2}}(\hat{X} + i\hat{P}), \qquad a^\dagger = \frac{1}{\sqrt{2}}(\hat{X} - i\hat{P})$

$\hat{X} = \frac{1}{\sqrt{2}}(a^\dagger + a), \qquad \hat{P} = \frac{i}{\sqrt{2}}(a^\dagger - a)$

$[a, a^\dagger] = 1 \qquad \hat{H} = a^\dagger a + \frac{1}{2}, \qquad N = a^\dagger a$

$[N, a] = -a, \qquad [N, a^\dagger] = a^\dagger$

$a^\dagger|\phi_n\rangle = \sqrt{n+1}|\phi_{n+1}\rangle$

$a|\phi_n\rangle = \sqrt{n}|\phi_{n-1}\rangle$

$\phi_0(x) = \sqrt{\frac{\beta}{\sqrt{\pi}}}e^{-\frac{\beta^2 x^2}{2}}$

$\phi_1(x) = \sqrt{\frac{\beta}{2\sqrt{\pi}}}(2\beta x)e^{-\frac{\beta^2 x^2}{2}}$

$\phi_2(x) = \sqrt{\frac{\beta}{8\sqrt{\pi}}}(4\beta^2 x^2 - 2)e^{-\frac{\beta^2 x^2}{2}}$

$\phi_3(x) = \sqrt{\frac{\beta}{48\sqrt{\pi}}}(8\beta^3 x^3 - 12\beta x)e^{-\frac{\beta^2 x^2}{2}}$