(1) Modern Quantum Mechanics, Problem 2.9.

(2) Modern Quantum Mechanics, Problem 2.19. This problem is about quantum optics. See R. J. Glauber, Phys.Rev.84(1951)395 and his Nobel lecture in Rev.Mod.Phys.78(2006)1267. Note that $P_n(\mu) = e^{-\mu} \mu^n / n!$ is the Poisson distribution of integers $n$ with a mean $\mu$, and the “most probable” value of $n$ is an integer. The problem includes a reference to Gottfried 1966, 262–264, for a theorem needed to solve it, namely

$$e^{A+B} = e^A e^B e^{-[A,B]/2}$$

for two operators $A$ and $B$ that commute with $[A, B]$. You can assume this without proof.

(3) Modern Quantum Mechanics, Problem 2.21.

(4) Modern Quantum Mechanics, Problem 2.24. There are various ways to solve the attractive $\delta$-function potential problem, but the simplest is to integrate the Schrödinger Equation across $x = 0$ to find the quantization condition.

(5) Use the WKB method to find the (approximate) solutions for the one-dimensional simple harmonic oscillator potential $V(x) = m \omega^2 x^2 / 2$. Does the answer surprise you?

(6) Derive an expression for the action of the position operator on an arbitrary state in the momentum representation. That is, find $\langle p'|x|\alpha \rangle$ in terms of $\langle p'|\alpha \rangle$. Use this to solve the linear potential (2.5.30) problem in momentum space, and show that the Fourier transform of your solution is indeed the appropriate Airy function. Note that an alternative form of the Airy function (see http://dlmf.nist.gov/9.5) is

$$Ai(x) = \frac{1}{\pi} \int_0^\infty \cos \left( \frac{1}{3} t^3 + xt \right) dt$$

You need not be concerned with normalizing the wave function.