PHY 341 HW Ch.1b

Do problems 1.14, 1.17 (a-c), 1.16*, 2.3*; plus the following (*=optional bonus):

q1-4
Download and run the program `avg-freefall.ipynb` discussed in class and available on the course site. Once it's working, modify it to calculate $\langle x^2 \rangle$. You need to make only a minimal change to the `for` loop to accomplish this. Calculate the uncertainty $\sigma_x = \sqrt{\langle x^2 \rangle - \langle x \rangle^2}$, and compare it with the results from Problem 1.2.
Also attach a histogram graph of $\langle x^2 \rangle$.

q1-5
The wave function of a particle of mass m is given by $\Psi(x,t) = A \exp(-\alpha x^2 - i\beta t)$, where A, α, β are positive constants. Hints: use the integral formula sheet on the course website (or the back cover).
(a) Find the normalization constant A.
(b) Find the potential energy $V(x)$ from the Schrödinger equation.
(c) Compute $\langle x \rangle$, $\langle x^2 \rangle$, $\langle p \rangle$, and $\langle p^2 \rangle$.
(d) Find the uncertainty $\sigma_x \times \sigma_p$, and comment on the result.

q1-6
The wave function $\Psi(x,0)$ at $t = 0$ is given by

$$\Psi(x,0) = c_1\psi_1(x) + c_2\psi_2(x) + c_3\psi_3(x),$$

where ψ_j are stationary states with energies E_j, and c_j the expansion constants ($j = 1, 2, 3$), respectively.
(a) Is $\Psi(x,0)$ a stationary state? Why?
(b) Write down the wave function at later times t.
(c) If a measurement of energy is made, what are the possible values?

Hints: For Problem 1.14, use the identity on the formula sheet or consult Eq. (1.25).