Phy 632: Problem Set 3
(Due: March 1, 2011)

16). Kardar, Ch. 3, Problem #11.

17). Consider a system of N particles with an associated PDF of $\rho(\{\mathbf{p_i}\}, \{\mathbf{q_i}\}, \mathbf{t})$.

a) Write an expression for the ensemble average of an observable $\mathcal{O}(\{\mathbf{p_i}\}, \{\mathbf{q_i}\}, \mathbf{t})$ and determine $d\langle\mathcal{O}\rangle/dt$. How does your expression compare with the quantum mechanical expression for $d\langle A\rangle/dt$ where $\langle A\rangle$ is the expectation value of A?

b) Suppose in equilibrium $\rho = \rho_{\rm eq}(H(p,q))$, where H is the Hamiltonian of the system. Compute the Poisson bracket of ρ with H in this case. What does your result imply for $d\langle\mathcal{O}\rangle/dt$?

18). Kardar, Ch. 3, Problem #12.

19). Kardar, Ch. 2, Problem #10.

20). Suppose the flux of moderated neutrons exiting a source have a distribution in speed v controlled by the function $\exp(-\xi v^2)$, where the root-mean-square speed $\bar{v}$ is roughly 900 m/s.

a) Find the unbiased probability distribution $p(v)$ of neutrons moving in one dimension subject to the constraint that the average speed is $\bar{v}$.

b) Interpreting the distribution in speed of the moderated neutrons as a PDF, compare the information content of this distribution with that of part a). Which one is larger? Why?

21). Revisit the moderated neutron source of #20. Assuming no inelastic processes operate, what is the maximum fraction of moderated neutron flux which can be used to produce ultracold neutrons (UCNs) from that source? For the purpose of this problem we suppose that a UCN has a kinetic energy no larger than 300 neV, and we recall that the neutron mass is roughly 940 MeV. Describe the operative physical principle which determines your answer.