Week 4 Worksheet
(Nondegenerate) Peturbation Theory

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Exercise 1. Suppose you want to calculate the expectation value of some observable A in the n^{th} energy eigenstate of a system perturbed by H^1,

$$\langle A \rangle = \langle n|A|n\rangle.$$

Suppose further that all eigenstates are nondegenerate.

a) Replace $|n\rangle$ by its perturbation expansion, and write down the formula for the first order correction to $\langle A\rangle$, $\langle A\rangle^1$.

b) Use the first order corrections to the states,

$$|n^1\rangle = \sum_{m\neq n} \frac{\langle m^0|\, H^1\, |n^0\rangle}{E_n^0 - E_m^0}\, |m^0\rangle\,,$$

to rewrite $\langle A\rangle^1$ in terms of the unperturbed eigenstates.

c) If $A = H^1$, what does the result of (b) tell you? Explain why this is consistent with the second order corrections to the energies,

$$E_n^2 = \sum_{m\neq n} \frac{|\,\langle m|H^1|n\rangle\,|^2}{E_n^0 - E_m^0}.$$