Physics G6038 Professor Christ
due 02/15/2026

Problem Set #14

55. The nucleus of a tritium atom ($Z = 1$, $A = 3$) decays into an He^3 nucleus emitting a 17 KeV electron. If the tritium atom was in the ground state, calculate the numerical values of the probabilities that the resulting He^+ ion is found in the $1s$, $2s$ or $2p$ states. Justify any approximation that you make.

56. Consider a one-dimensional harmonic oscillator with Hamiltonian

$$H = \frac{p^2}{2m} + \frac{1}{2}m\omega^2(x - x_0)^2$$

If the oscillator is initially in its ground state, find the energy transferred if

(a) x_0 is slowly changed to $x_0' = x_0 + D$.

(b) x_0 is suddenly changed to $x_0' = x_0 + D$.

(c) ω is slowly changed to ω'.

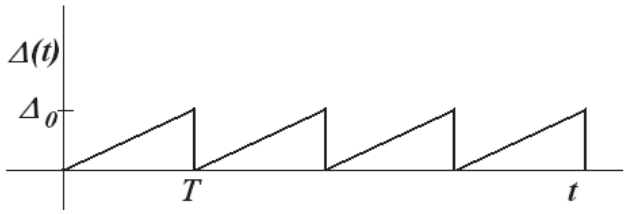
(d) ω is suddenly changed to ω'.

57. Consider a particle moving in a simple harmonic potential in one dimension with the Hamiltonian:

$$H = \frac{p^2}{2m} + \frac{1}{2}m\omega^2\Big(x - \Delta(t)\Big)^2.$$

The displacement $\Delta(t)$ depends on time in the following way:

$$\Delta(t) = \Delta_0\{t/T - \text{int}(t/T)\},$$



where $\text{int}(r)$ denotes the integer part of the real number r. Assume that $m(\Delta_0/T)^2 \ll \hbar\omega$, that the function $\Delta(t)$ returns rapidly to zero when t/T is an integer and that the system is in the ground state at $t = 0$.

(a) What is the state just before $t = T$?

(b) What is the state just after $t = T$?

(c) How much energy has been transferred to the system just after $t = T$?

(d) What is the state just after $t = 2T$ and what is the total energy transfer?

(e) How much energy has been transferred in total to the system just after $t = NT$ where N is an integer and what is the resulting state?