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1. Professor Kwan Kim from the University of Seoul studied the effect of impurities on the conductivity of nanotubes in *Journal of Nanotube Technology*, **92**, p. 1623 (2003). We may describe the motion of electrons on the nanotube by a 1D Schrödinger equation, with impurities represented by delta potentials. Here we are interested in mutual effects of two impurities at a distance a, one being attractive and the other repulsive, which gives the Hamiltonian $H = \frac{1}{2m}p^2 - W_0(\delta(x) - \delta(x-a))$.

   - Find the transcendental equation that determines the bound state of such a potential.
   - Under what system parameters does there exist a bound state? If the bound state exists for all parameters demonstrate this mathematically.

2. The HF molecule oscillates with the angular frequency $\omega = 5 \times 10^{14} s^{-1}$ and is initially found in the ground state of this oscillatory mode. The Hamiltonian can be written as $H = \frac{1}{2M}p^2 + \frac{1}{2}M\omega^2 x^2$, where $M = 1.6 \times 10^{-27} kg$ represents the reduced mass of the system. At the time $t = 0$ we immediately switch on the electric field that contributes an additional potential $V = e_0 E x$, where $e_0 = 1.6 \times 10^{-19} As$ and $E = 5 \times 10^{10} V/m$ ($\hbar = 1.05 \times 10^{-34} Js$).

   - After switching on the electric field, what is the probability to find the molecule in the ground state of the new potential?
   - At what time after switching on the electric field does the molecule find itself in the state with the maximum (in terms of its absolute value) expectation value of the momentum p for the first time? What is the value of the momentum at that point and what is its uncertainty?