(1) A particle of mass $m$ moves along one of two “paths” through space and time connecting the points $(x, t) = (0, 0)$ and $(x, t) = (D, T)$. One path is quadratic in time, i.e. $x_1(t) = \frac{1}{2}at^2$ where $a$ is a constant. The second path is linear in time, i.e. $x_2(t) = vt$ where $v$ is a constant. The correct classical path is the quadratic path, that is $x_1(t)$.

a. Find the acceleration $a$ for the correct classical path. Use freshman physics to find the force $F = ma = -dV/dx$ and then the potential energy function $V(x)$ in terms of $m$, $D$, and $T$. Also find the velocity $v$ for the linear (i.e. incorrect classical) path.

b. Calculate the classical action $S[x(t)] = \int_0^T \left[ \frac{1}{2}m\dot{x}^2 - V(x) \right] dt$ for each of the two paths $x_1(t)$ and $x_2(t)$. Confirm that $S_1 \equiv S[x_1(t)] < S_2 \equiv S[x_2(t)]$, and find $\Delta S = S_2 - S_1$.

c. Calculate $\Delta S/\hbar$ for a particle which moves 1 mm in 1 ms for two cases. The particle is a nanoparticle made up of 100 carbon atoms in one case. The other case is an electron. For which of these would you consider the motion “quantum mechanical” and why?

(2) *Modern Quantum Mechanics*, Problem 2.28. The history of flux quantization is quite fascinating. The original discovery can be found in B. S. Deaver and W. M. Fairbank, “Experimental Evidence for Quantized Flux in Superconducting Cylinders”, Phys. Rev. Lett. 7(1961)43. The flux quantum worked out to be $\hbar c/2e$, but it was later appreciated that the charge carriers were Cooper pairs of electrons. See also articles by Deaver and others in “Near Zero: new frontiers of physics”, by Fairbank, J. D.; Deaver, B. S., Jr.; Everitt, C. W. F.; Michelson, P. F.. Freeman, 1988.

(3) *Modern Quantum Mechanics*, Problem 2.32.

(4) *Modern Quantum Mechanics*, Problem 3.2.

(5) *Modern Quantum Mechanics*, Problem 3.3. Interpret the action of “dividing by a matrix” as multiplication (on the right) by the inverse of that matrix.