# Year 3 General Physics — Quantum Mechanics

1. Make a rough sketch of the approximate form of the wave-functions corresponding to the ground state and to the third excited state for the potential $V=k|x|$ where $k$ is a constant.

2. Which of the following is the correct form of the ground state wave-function for a harmonic oscillator potential ( $V(x) \propto x^2$ )?

(A) $\psi_0(x)=A_0\exp(-ax^2)$ (B) $\psi_0(x)=A_0\exp(-ax)$

(C) $\psi_0(x)=A_0\sin(ax^2)$ (D) $\psi_0(x)=A_0\sin(ax)$

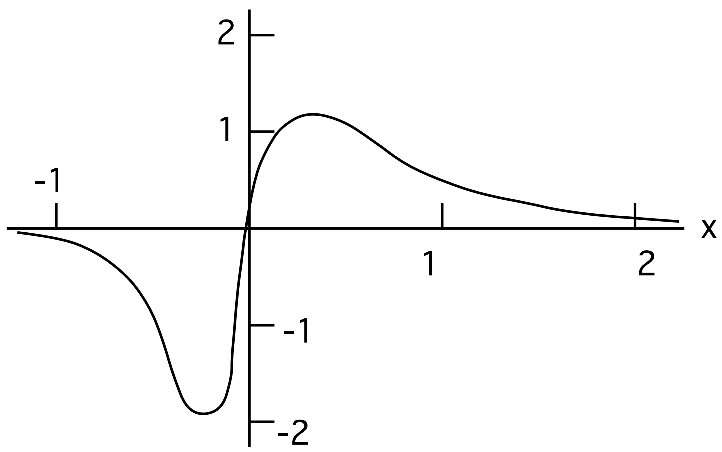
(E) $\psi_0(x)=A_0\exp(ax^2)$

3. A particle is in a 1-dimensional square well potential which has zero potential inside and infinite potential outside. One possible energy level for the particle inside the well has a wave-function which is zero at *three* points: at both edges of the well and at one point inside the well. A second possible energy level for the same particle inside the well has a wave-function which is zero at *four* points. What is the *ratio* of the energy of the second state to that of the first state?

4. A particle initially moving in a region of zero potential and with kinetic energy $E$ approaches an abrupt potential drop to a potential $V_o = -2E$. What is the probability that the particle will be reflected? What happens to the particle's wavelength on the two sides of the potential drop?

5. What is the ratio of neutron to electron kinetic energy required to obtain the same De Broglie wavelength (assume the particles are non-relativistic).

6. The dependence of a one-dimensional wave function on position at a certain time is shown below. If a measurement which could locate the associated particle in an element $\Delta x$ of the $x$ axis were made at that time, is the particle more likely to be found at a negative or a positive position coordinate $x$ ? What is the most likely position at which to find the particle?



7. Sketch the ground state wave-function of a particle trapped in a one-dimensional box having zero potential in the box, but

(i) with infinite potential walls

(ii) with large but finite potential walls

Which has the lower energy and why?
For case (i), compare the energy of the lowest energy state determined from the solution of the Schrödinger equation with that obtained from the uncertainty relation.
For case (ii), what is the characteristic distance by which the wave-function penetrates the walls?

8. Show that the wave function $\Psi = A.\exp(ikx)$ is a solution to both the momentum and energy eigenvalue equations in a constant potential. What is the significance of this for the measurement of these variables?