Chapter 7

Rounded Well

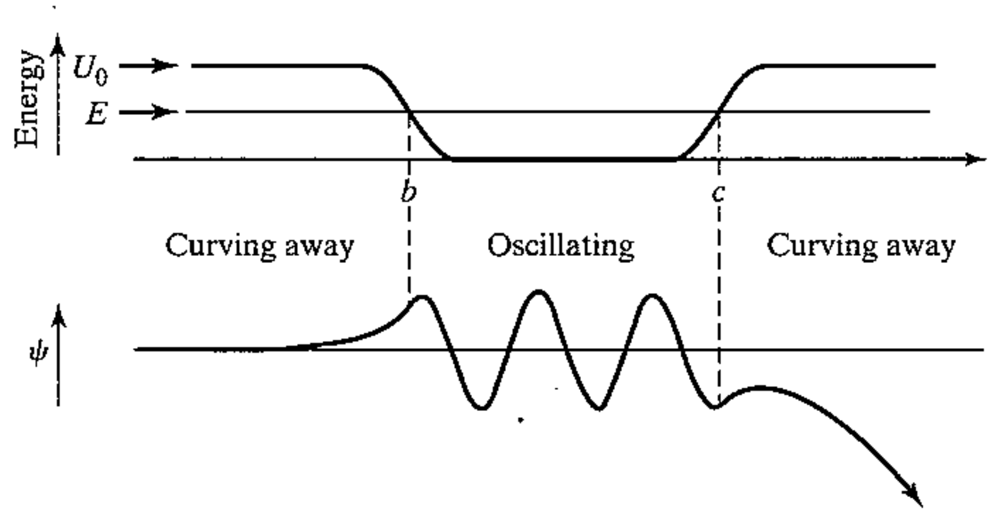


FIGURE 7.13

The wave function oscillates between the two turning points $x = b$ and $x = c$ and curves away from the axis outside them. The example shown is well behaved as $x \rightarrow -\infty$, but blows up as $x \rightarrow +\infty$.

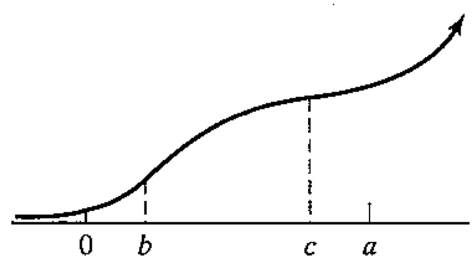


FIGURE 7.14

When E is very small, the wave function bends too slowly inside the well. The function that has the form $Ae^{\alpha x}$ when $x < 0$ blows up as $x \rightarrow +\infty$.

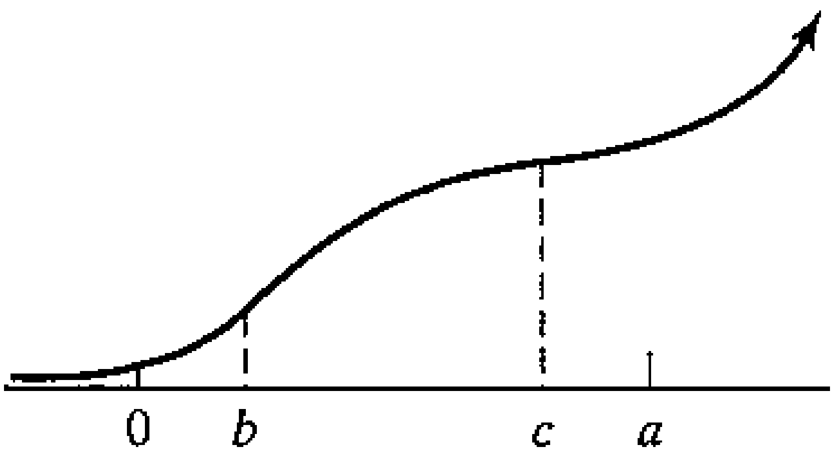


FIGURE 7.14

When E is very small, the wave function bends too slowly inside the well. The function that has the form $Ae^{\alpha x}$ when $x < 0$ blows up as $x \longrightarrow +\infty$.

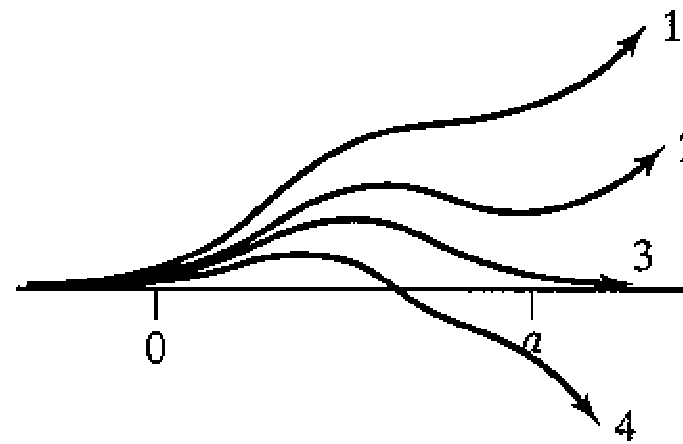


FIGURE 7.15

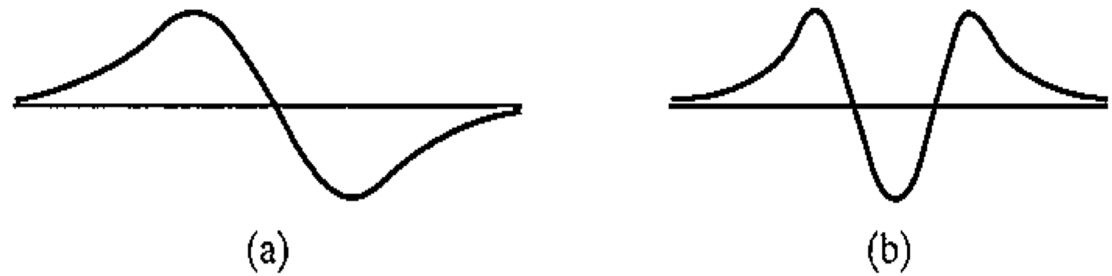
Solutions of the Schrödinger equation for four successively larger energies. All four solutions have the well-behaved form $Ae^{\alpha x}$ for $x < 0$, but only number 3 is also well behaved as $x \longrightarrow +\infty$.

$$\psi(x) = Ae^{\alpha x} + Be^{-\alpha x} \quad \text{outside well}$$

$$\psi(x) = F\sin kx + G\cos kx \quad \text{inside well}$$

FIGURE 7.16

Wave functions for the second and third energy levels of a nonrigid box.



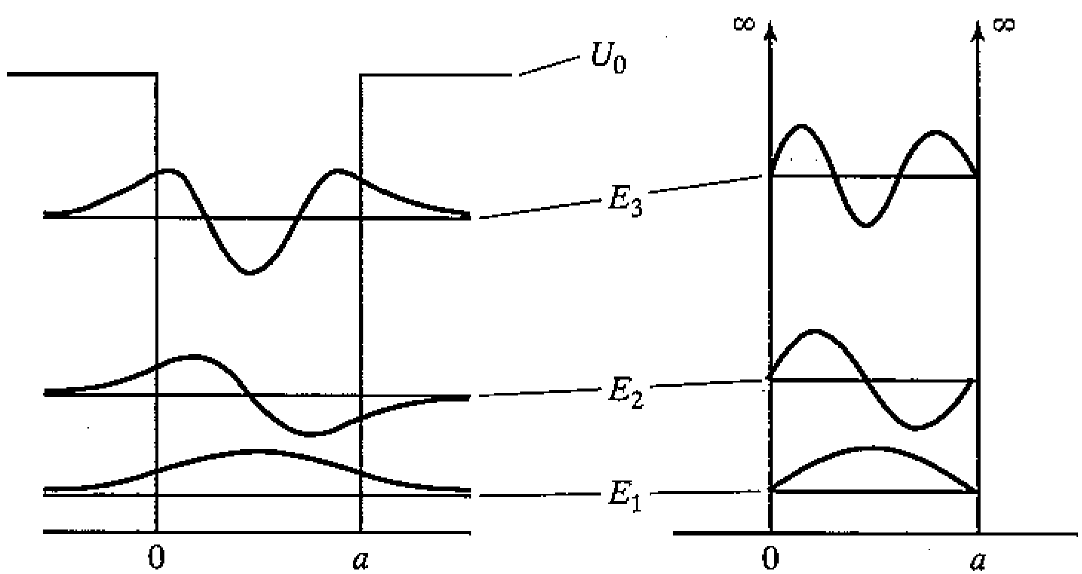
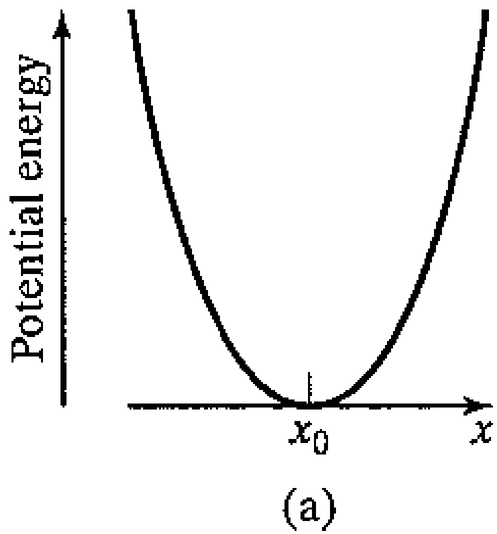


FIGURE 7.17

The lowest three energy levels and wave functions for a finite square well and for an infinite square well of the same width. The horizontal lines that represent each energy level have been used as the axes for drawing the corresponding wave functions.

Harmonic Oscillator



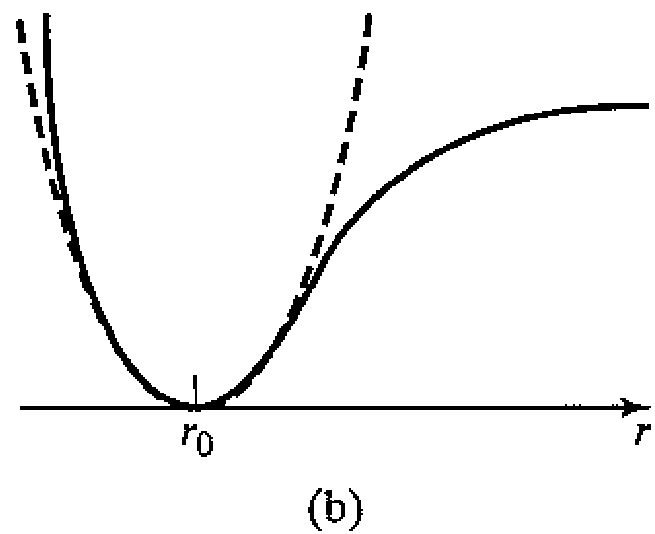


FIGURE 7.18

(a) The potential energy of an ideal simple harmonic oscillator is a parabola. **(b)** The potential energy of a typical diatomic molecule (solid curve) is well approximated by that of an SHO (dashed curve) when r is close to its equilibrium value r_0.

Diatomic molecule potential

Harmonic Oscillator Wave Functions

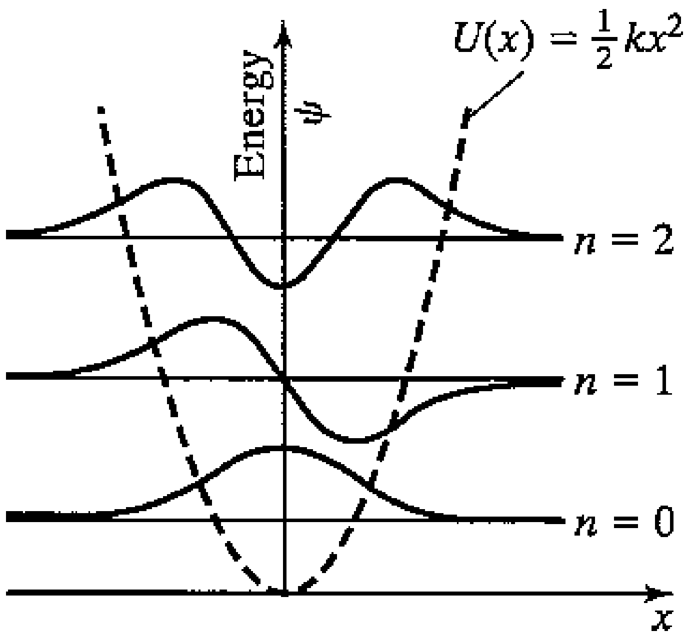


FIGURE 7.19

The first three energy levels and wave functions of the simple harmonic oscillator.

TABLE 7.1

The energies and wave functions of the first three levels of a quantum harmonic oscillator. The length b is defined as $\sqrt{\hbar/m\omega_c}$.

n	E_n	$\psi(x)$
0	$\frac{1}{2}\hbar\omega_c$	$A_0 e^{-x^2/2b^2}$
1	$\frac{3}{2}\hbar\omega_c$	$A_1 \frac{x}{b} e^{-x^2/2b^2}$
2	$\frac{5}{2}\hbar\omega_c$	$A_2\left(1 - 2\frac{x^2}{b^2}\right)e^{-x^2/2b^2}$

Harmonic Oscillator Energy Levels

Harmonic Oscillator Diatomic Molecule

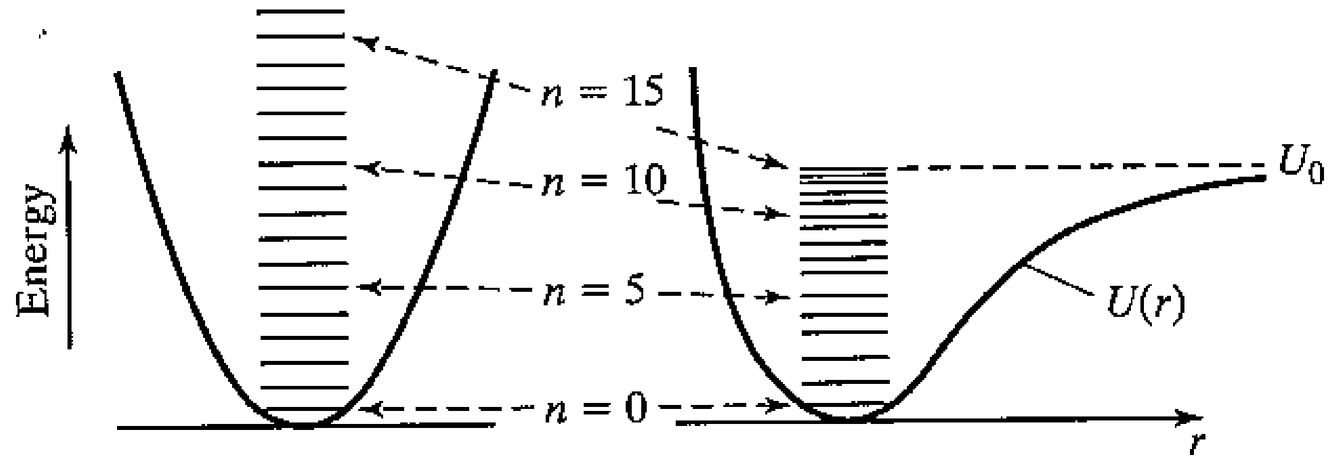


FIGURE 7.20

Vibrational levels of a typical diatomic molecule (right) and the SHO that approximates the molecule for small displacements (left). The first five or so levels correspond very closely; the higher levels of the molecule are somewhat closer together, and the molecule has no levels above the energy U_0.

Tunnel Barrier

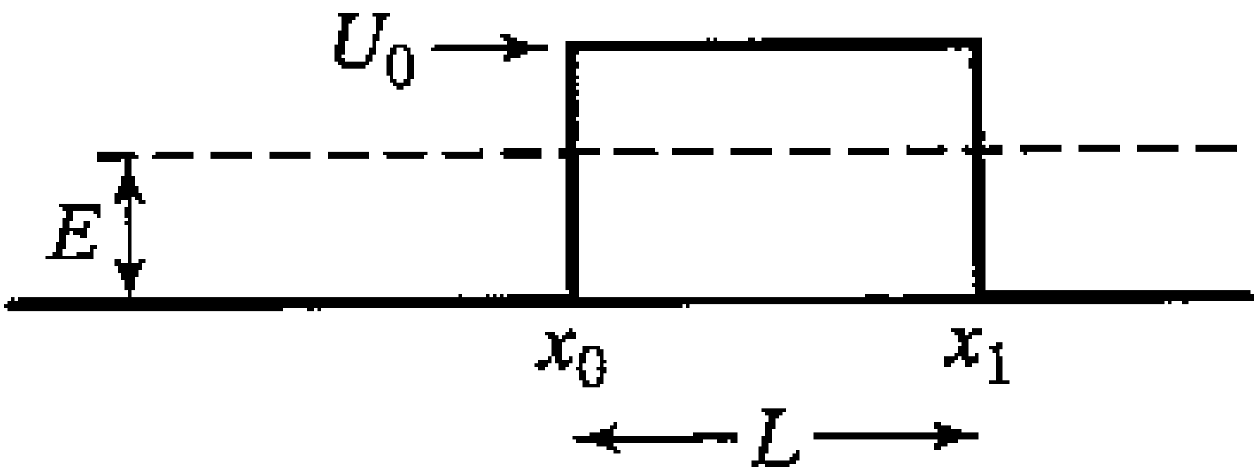


FIGURE 7.21

A rectangular barrier of height U_0 and width L.

Tunneling Wave Function

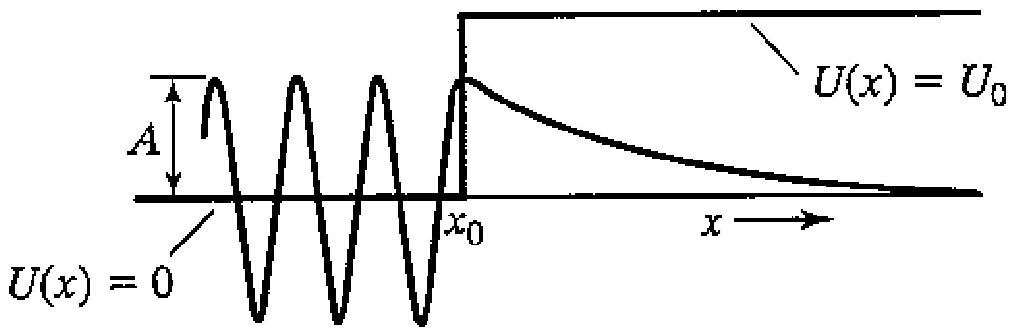


FIGURE 7.22

A rectangular barrier of infinite length, with $U(x) = U_0$ for $x_0 < x < \infty$. The wave function is sinusoidal with amplitude A when $x < x_0$, and decreases exponentially when $x > x_0$.

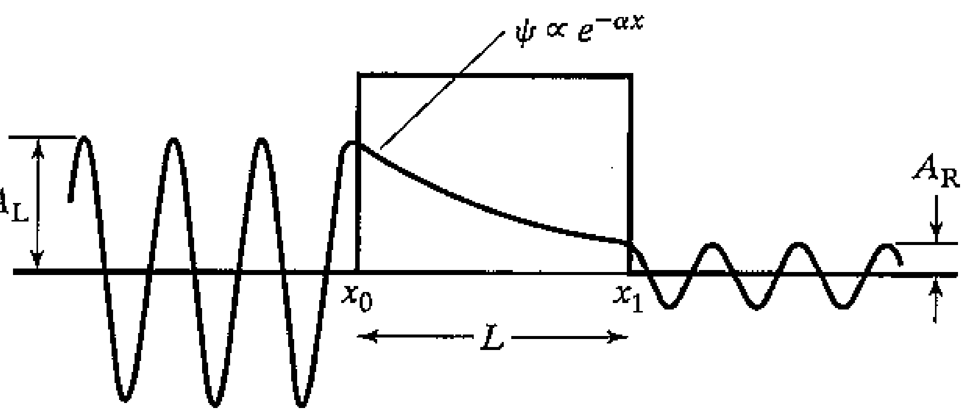


FIGURE 7.23

Wave function for a barrier of finite length. On the left $(x < x_0)$, $\psi(x)$ is sinusoidal, with amplitude A_L; in the barrier it decreases exponentially; on the right $(x > x_1)$, it is sinusoidal again, with amplitude A_R.