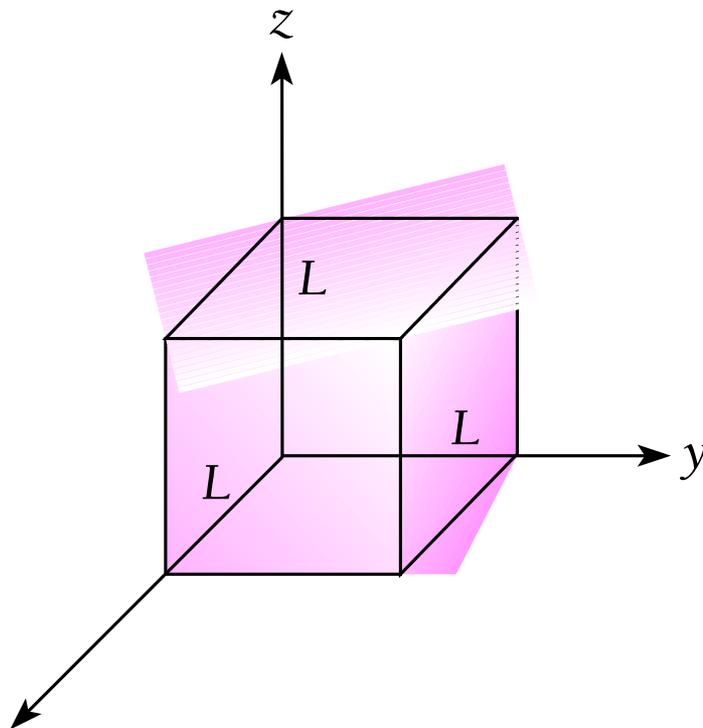




Three-Dimensional Quantum Well (Quantum Dot)

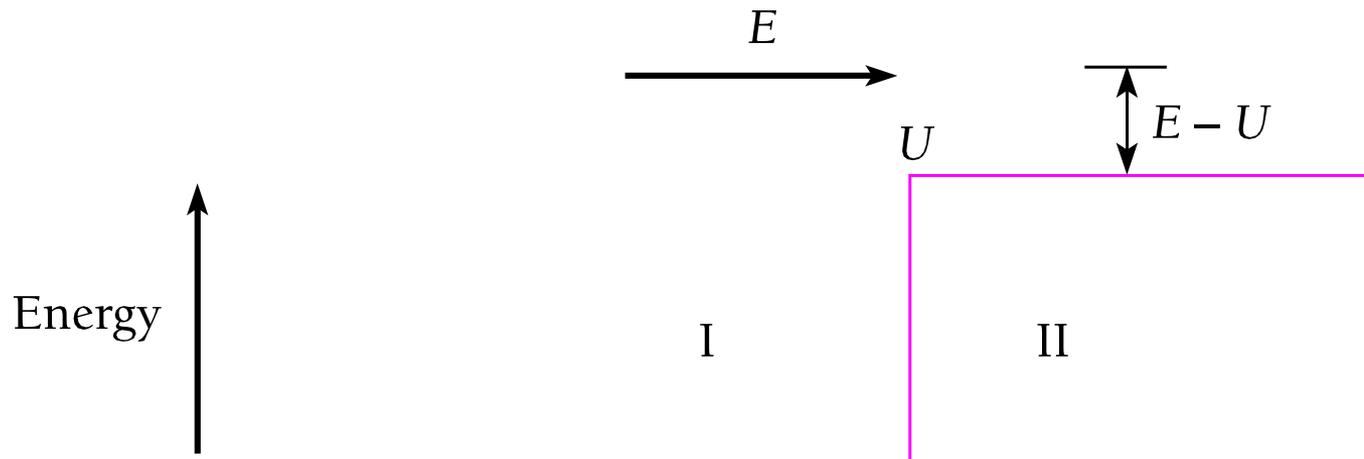


Degeneracy

그림 5.18 정육면체 상자.

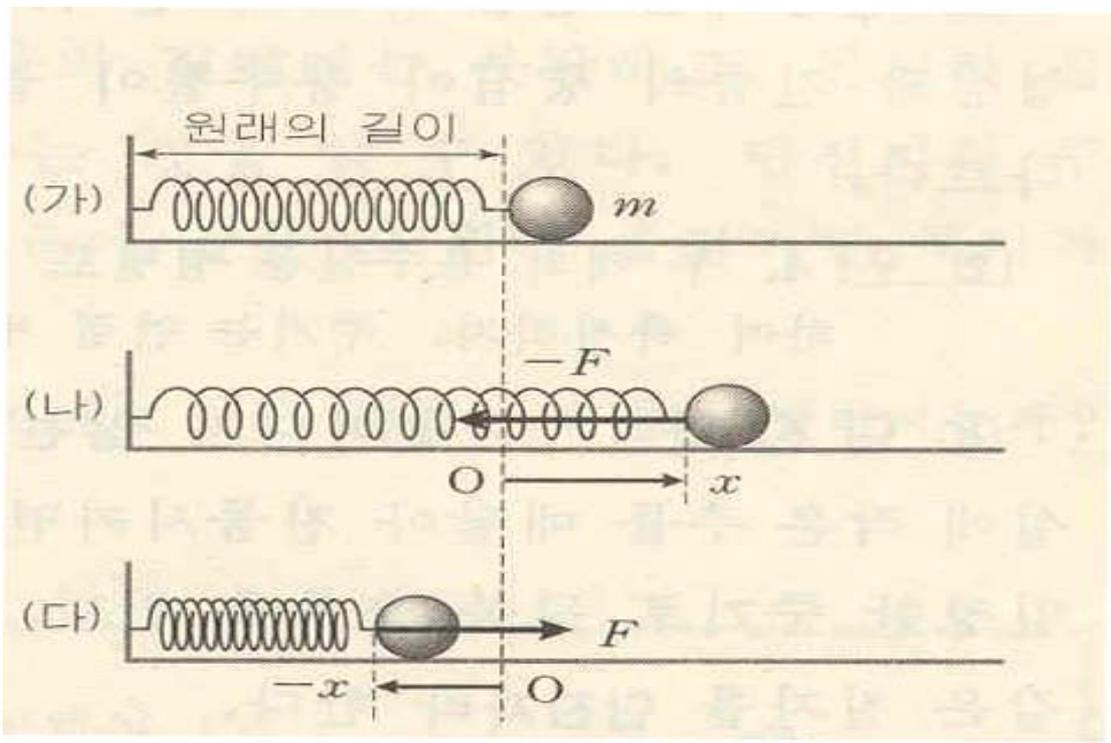


Potential Step





Harmonic Oscillator (조화진동자)



$$F = -kx = m \frac{d^2 x}{dt^2}$$

$$H = \frac{p^2}{2m} + \frac{m\omega^2 x^2}{2}$$

$$\omega = \sqrt{\frac{k}{m}}$$

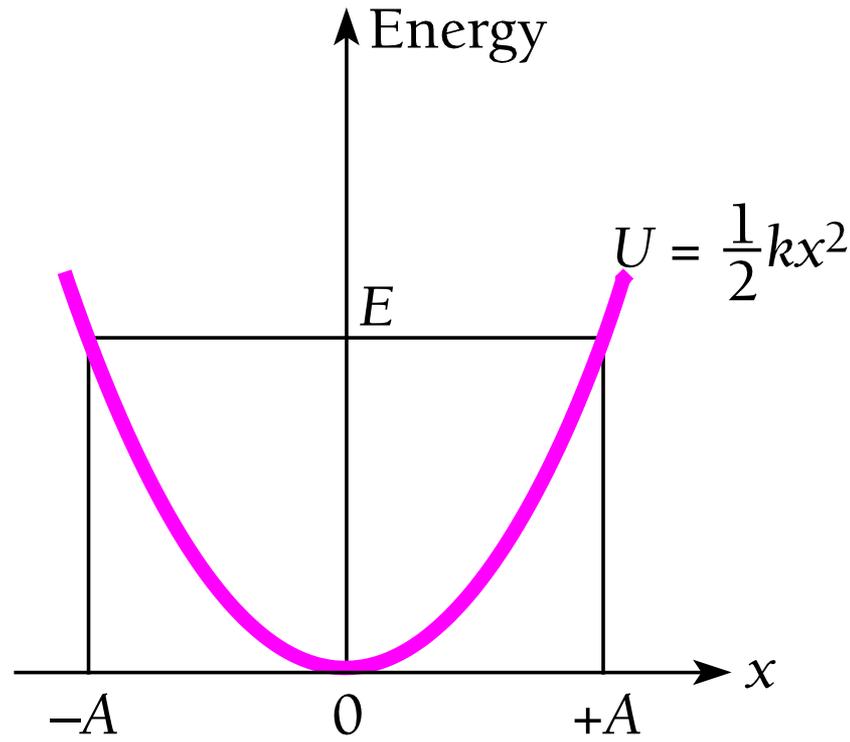
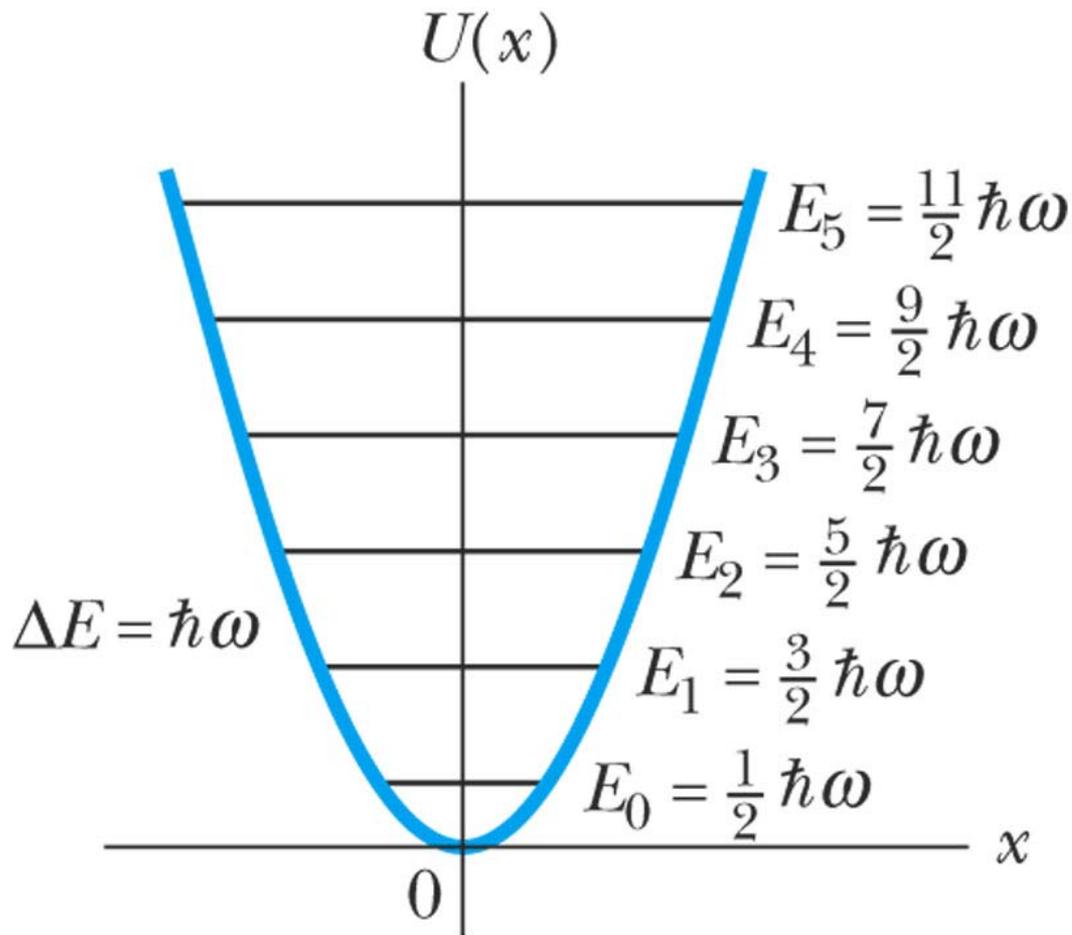


그림 5.10 조화 진동자의 퍼텐셜 에너지는 평형 위치로부터의 변위인 x 의 제곱, 즉 x^2 에 비례한다. 운동의 진폭 A 는 고전적으로는 어떤 값이라도 다 가질 수 있는 진동자의 총 에너지 E 에 의해 결정된다.



$$E_n = \left(n + \frac{1}{2} \right) \hbar \omega,$$
$$n = 0, 1, 2, 3, \dots$$

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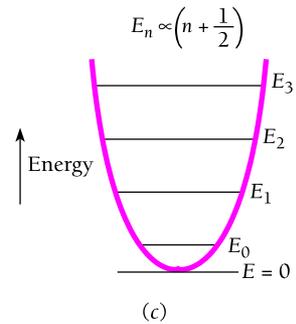
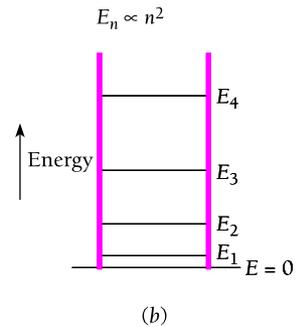
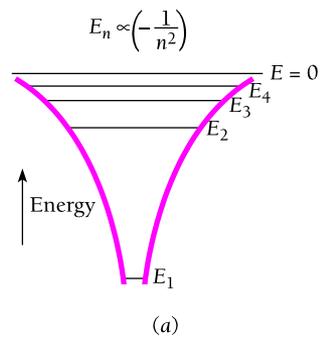
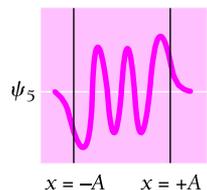
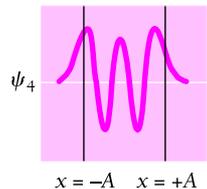
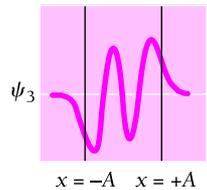
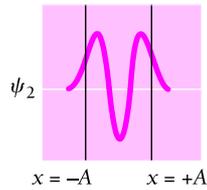
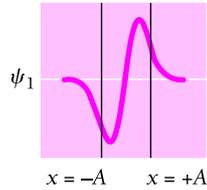
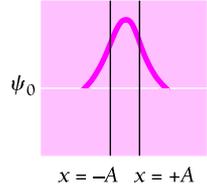


그림 5.11 퍼텐셜 우물과 에너지 준위 (a) 수소원자, (b) 상자 안의 입자 (c) 조화 진동자. 각 경우에 에너지 준위는 서로 다른 방법으로 양자수 n 에 의존한다. 조화 진동자만이 일정한 간격의 에너지 준위를 가진다.



$$\psi_n = \left(\frac{2m\nu}{\hbar} \right)^{1/4} (2^n n!)^{-1/2} H_n(y) e^{-y^2/2}$$

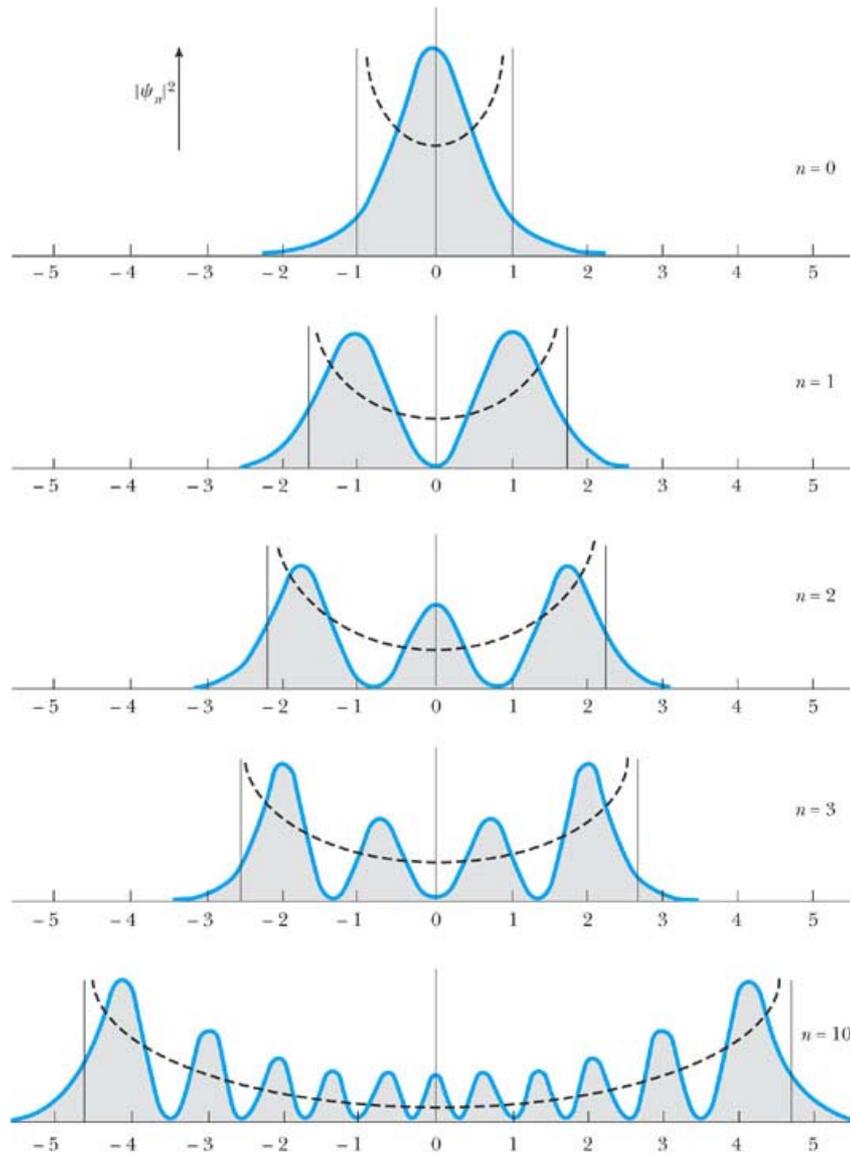
$$y = \sqrt{\frac{2\pi m\nu}{\hbar}} x$$

표 5.2 몇개의 Hermite 다항식

n	H _n (y)	α _n	E _n
0	1	1	$\frac{1}{2}h\nu$
1	2y	3	$\frac{3}{2}h\nu$
2	4y ² - 2	5	$\frac{5}{2}h\nu$
3	8y ³ - 12y	7	$\frac{7}{2}h\nu$
4	16y ⁴ - 48y ² + 12	9	$\frac{9}{2}h\nu$
5	32y ⁵ - 160y ³ + 120y	11	$\frac{11}{2}h\nu$

그림 5.12 처음부터 여섯 번째까지의 조화 진동자 파동함수. 수직선은 같은 에너지를 가진 고전 진동자가 진동할 수 있는 경계를 나타낸다.



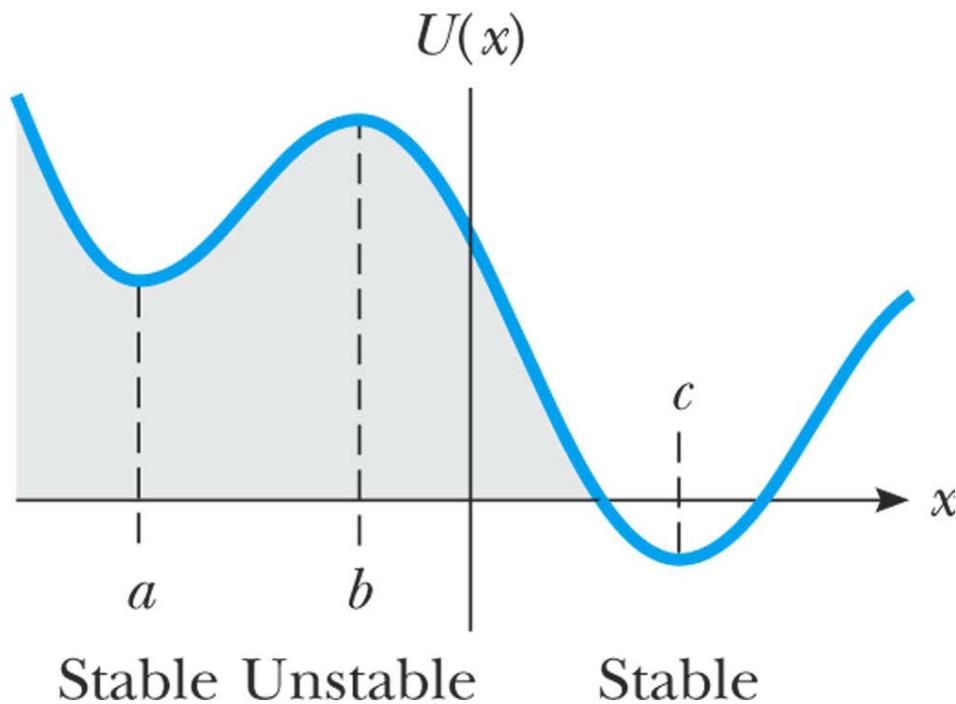


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Why Harmonic Oscillator is so Important



$$F(x) = F_{x=0} + \left(\frac{dF}{dx} \right)_{x=0} x + \frac{1}{2} \left(\frac{d^2 F}{dx^2} \right)_{x=0} x^2 + \dots$$

$$F(x) = \left(\frac{dF}{dx} \right)_{x=0} x$$

$$U(x) = -\int_0^x F(x) dx = \frac{1}{2} kx^2$$

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Feynman



Richard P. Feynman
(1918-1988)

"The theory of quantum electrodynamics describes Nature as absurd from the point of view of common sense. And it fully agrees with experiment. So I hope you can accept Nature as She is - absurd."

