From “GRE: Practicing to take the physics test” 3rd edition (ETS: 1997)

1.

Eigenfunctions for a rigid dumbbell rotating about its center have a ϕ dependence of the form $\psi(\phi) = Ae^{im\phi}$, where m is a quantum number and A is a constant. Which of the following values of A will properly normalize the eigenfunction?

(A) $\sqrt{2\pi}$

(B) 2π

(C) $(2\pi)^2$

(D) $\frac{1}{\sqrt{2\pi}}$

(E) $\frac{1}{2\pi}$

2.

Which of the following is an eigenfunction of the linear momentum operator $-i\hbar\frac{\partial}{\partial x}$ with a positive eigenvalue $\hbar k$; i.e., an eigenfunction that describes a particle that is moving in free space in the direction of positive x with a precise value of linear momentum?

(A) $\cos kx$ (B) $\sin kx$ (C) e^{-ikx}

(D) e^{ikx} (E) e^{-kx}

3.

A system containing two identical particles is described by a wave function of the form

$$\psi = \frac{1}{\sqrt{2}}[\psi_\alpha(x_1)\,\psi_\beta(x_2) + \psi_\beta(x_1)\,\psi_\alpha(x_2)]$$

where x_1 and x_2 represent the spatial coordinates of the particles and α and β represent all the quantum numbers, including spin, of the states that they occupy. The particles might be

(A) electrons
(B) positrons
(C) protons
(D) neutrons
(E) deuterons

4.

The wave function of a particle is $e^{i(kx-\omega t)}$, where x is distance, t is time, and k and ω are positive real numbers. The x-component of the momentum of the particle is

(A) 0

(B) $\hbar\omega$

(C) $\hbar k$

(D) $\frac{\hbar\omega}{c}$

(E) $\frac{\hbar k}{\omega}$

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A system is known to be in the normalized state described by the wave function

$$\psi(\theta,\varphi) = \frac{1}{\sqrt{30}}(5\,Y_4^{\,3} + Y_6^{\,3} - 2\,Y_6^{\,0}),$$

where the $Y_\ell^{\,m}(\theta,\varphi)$ are the spherical harmonics. The probability of finding the system in a state with azimuthal orbital quantum number $m = 3$ is

(A) 0

(B) $\frac{1}{15}$

(C) $\frac{1}{6}$

(D) $\frac{1}{3}$

(E) $\frac{13}{15}$

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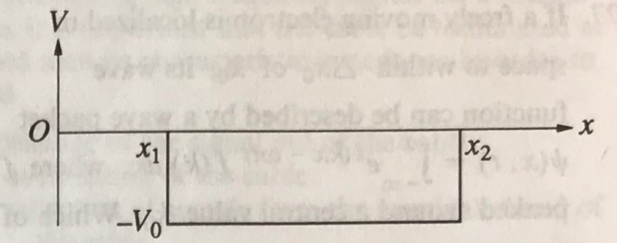
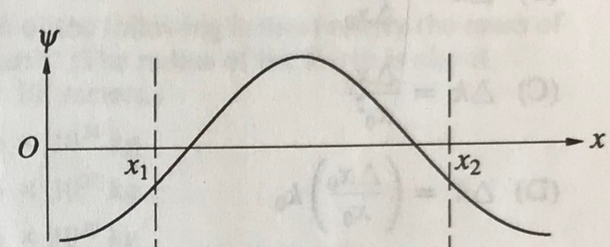


An attractive, one-dimensional square well has depth V_0 as shown above. Which of the following best shows a possible wave function for a bound state?

(A)



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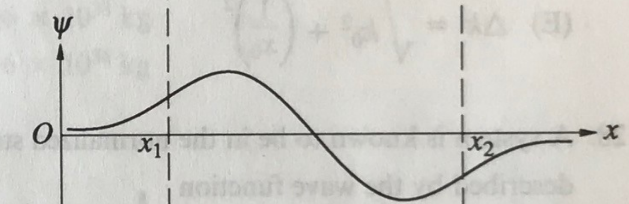

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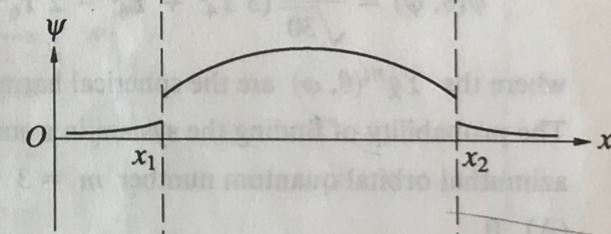

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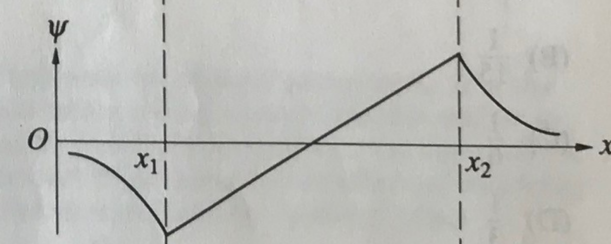
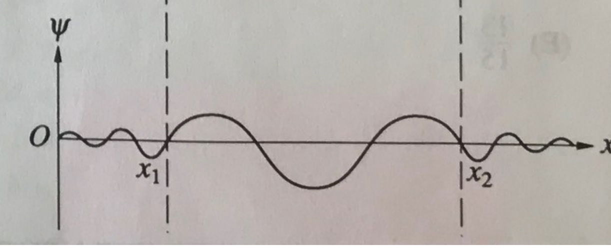


(E)



7 – 9

Questions 51-53

A particle of mass m is confined to an infinitely dee
square-well potential:

$$V(x) = \infty, x \le 0, x \ge a$$
$$V(x) = 0, 0 < x < a.$$

The normalized eigenfunctions, labeled by the quantu
number n, are $\psi_n = \sqrt{\frac{2}{a}} \sin \frac{n\pi x}{a}$.

51. For any state n, the expectation value of the momentum of the particle is

(A) 0

(B) $\frac{\hbar n\pi}{a}$

(C) $\frac{2\hbar n\pi}{a}$

(D) $\frac{\hbar n\pi}{a}(\cos n\pi - 1)$

(E) $\frac{-i\hbar n\pi}{a}(\cos n\pi - 1)$

52. The eigenfunctions satisfy the condition $\int_0^a \psi_n^*(x)\,\psi_\ell(x)\,dx = \delta_{n\ell}$, $\delta_{n\ell} = 1$ if $n = \ell$, otherwise $\delta_{n\ell} = 0$. This is a statement that the eigenfunctions are

(A) solutions to the Schrödinger equation
(B) orthonormal
(C) bounded
(D) linearly dependent
(E) symmetric

53. A measurement of energy E will always satisfy which of the following relationships?

(A) $E \le \frac{\pi^2\hbar^2}{8ma^2}$

(B) $E \ge \frac{\pi^2\hbar^2}{2ma^2}$

(C) $E = \frac{\pi^2\hbar^2}{8ma^2}$

(D) $E = \frac{n^2\pi^2\hbar^2}{8ma^2}$

(E) $E = \frac{\pi^2\hbar^2}{2ma^2}$

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The configuration of three electrons ls2p3p has which of the following as the value of its maximum possible total angular momentum quantum number?

(A) $\frac{7}{2}$

(B) 3

(C) $\frac{5}{2}$

(D) 2

(E) $\frac{3}{2}$

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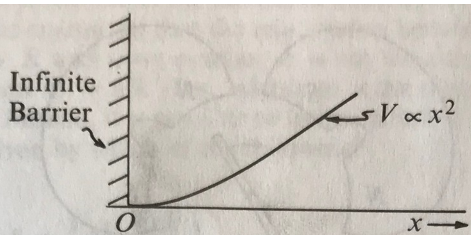

The energy levels for the one-dimensional harmonic oscillator are $h\nu\left(n+\frac{1}{2}\right)$, $n = 0, 1, 2 \ldots$. How will the energy levels for the potential shown in the graph above differ from those for the harmonic oscillator?

(A) The term $\frac{1}{2}$ will be changed to $\frac{3}{2}$.

(B) The energy of each level will be doubled.

(C) The energy of each level will be halved.

(D) Only those for even values of n will be present.

(E) Only those for odd values of n will be present.

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A diatomic molecule is initially in the state $\Psi(\Theta, \Phi) = (5Y_1^1 + 3Y_5^1 + 2Y_5^{-1})/(38)^{1/2}$, where Y_ℓ^m is a spherical harmonic. If measurements are made of the total angular momentum quantum number ℓ and of the azimuthal angular momentum quantum number m, what is the probability of obtaining the result $\ell = 5$?

(A) 36/1444
(B) 9/38
(C) 13/38
(D) $5/(38)^{1/2}$
(E) 34/38

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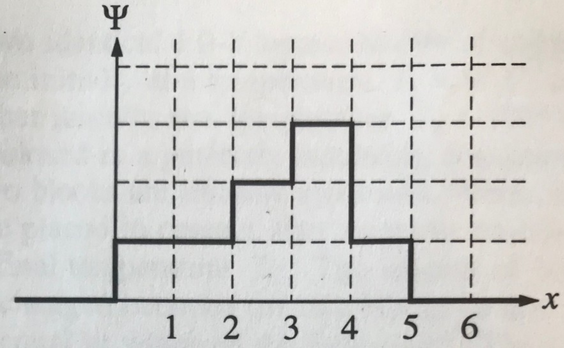

The wave function for a particle constrained to move in one dimension is shown in the graph above ($\Psi = 0$ for $x \leq 0$ and $x \geq 5$). What is the probability that the particle would be found between $x = 2$ and $x = 4$?

(A) 17/64

(B) 25/64

(C) 5/8

(D) $\sqrt{5/8}$

(E) 13/16