

Test Your fiziks concepts!**Topic: Quantum Mechanics****(For CSIR NET-JRF, GATE, JEST and TIFR Aspirants)**

Q. The ground state energy of a particle of mass m in the potential $V(x) = V_0 \cosh\left(\frac{x}{L}\right)$, where

L and V_0 are constants (with $V_0 \gg \frac{\hbar^2}{2mL^2}$) is approximately

(a) $V_0 + \frac{\hbar}{L} \sqrt{\frac{2V_0}{m}}$ (b) $V_0 + \frac{\hbar}{L} \sqrt{\frac{V_0}{m}}$ (c) $V_0 + \frac{\hbar}{4L} \sqrt{\frac{V_0}{m}}$ (d) $V_0 + \frac{\hbar}{2L} \sqrt{\frac{V_0}{m}}$

Ans.: (d)

Solution.: $V_0 = \cosh\left(\frac{x}{L}\right) = \frac{V_0}{2} (e^{x/L} + e^{-x/L})$

$$V_0 = \frac{V_0}{2} \left[1 + \frac{x}{L} + \frac{1}{2!} \left(\frac{x}{L}\right)^2 + \dots \right] + \frac{V_0}{2} \left[1 - \frac{x}{L} + \frac{1}{2!} \left(\frac{x}{L}\right)^2 + \dots \right] = \frac{V_0}{2} + \frac{V_0}{2} + \frac{V_0}{2} \left(\frac{x}{L}\right)^2 = V_0 + \frac{1}{2} \left(\frac{V_0}{L^2}\right) x^2$$

$$\Rightarrow k = \frac{V_0}{L^2}, \quad \omega = \sqrt{\frac{V_0}{mL^2}}$$

So, ground state energy is $V_0 + \frac{\hbar\omega}{2} = V_0 + \frac{\hbar}{2} \sqrt{\frac{V_0}{mL^2}} = V_0 + \frac{\hbar}{2L} \sqrt{\frac{V_0}{m}}$

Note:

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Test Your fiziks concepts!**Topic: Electronics****(For IIT-JAM, JEST, TIFR and CUET Aspirants)**

Q. Consider the circuit shown in the figure where $R_1 = 2.07\text{ k}\Omega$ and $R_2 = 1.93\text{ k}\Omega$. Current source I delivers 10 mA current. The potential across the diode D is 0.7 V . What is the potential at A ?

- (a) 10.35 V (b) 9.65 V
(c) 19.30 V (d) 4.83 V

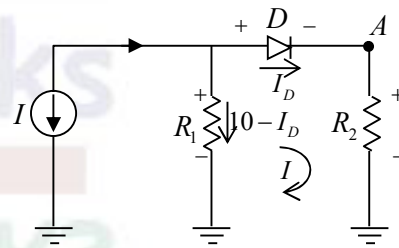
Ans.: (b)

Solution.: Apply KVL in loop I

$$0.7 + I_D R_2 - (10 - I_D) R_1 = 0$$

$$\Rightarrow 0.7 + I_D \times 1.93 - (10 - I_D) \times 2.07 = 0$$

$$\Rightarrow I_D = 5\text{ mA} \Rightarrow V_A = I_D R_2 = 5\text{ mA} \times 1.93\text{ k}\Omega = 9.65\text{ V}$$



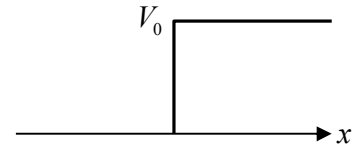
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Learn Physics in Right Way

Test Your fiziks concepts!**Topic: Modern Physics****(For PGT: KVS, NVS, DSSSB, State Education Boards, etc.)**

Q. Consider the motion of a quantum particle of mass m and energy E under the influence of a step potential of height V_0 . If R denotes the reflection coefficient, which one of the following statements is true?



(a) If $E = \frac{4}{3}V_0$, $R = 1$

(b) $E = \frac{4}{3}V_0$, $R = 0$

(c) $E = \frac{1}{2}V_0$, $R = 1$

(d) $E = \frac{1}{2}V_0$, $R = 0.5$

Ans.: (c)

Solution.: $E = \frac{V_0}{2} \Rightarrow E < V_0$. So, $R = 1$. Therefore, option (c) is correct.

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Test Your fiziks concepts!**Topic: Quantum Mechanics****(For CSIR NET-JRF, GATE, JEST and TIFR Aspirants)**

Q. A particle of mass m is in a cubic box of size a . The potential inside the box ($0 \leq x < a, 0 \leq y < a, 0 \leq z < a$) is zero and infinite outside. If the particle is in an eigenstate of energy $E = \frac{14\pi^2\hbar^2}{2ma^2}$, its wavefunction is

(a) $\psi = \left(\frac{2}{a}\right)^{3/2} \sin \frac{3\pi x}{a} \sin \frac{5\pi y}{a} \sin \frac{6\pi z}{a}$ (b) $\psi = \left(\frac{2}{a}\right)^{3/2} \sin \frac{7\pi x}{a} \sin \frac{4\pi y}{a} \sin \frac{3\pi z}{a}$

(c) $\psi = \left(\frac{2}{a}\right)^{3/2} \sin \frac{4\pi x}{a} \sin \frac{8\pi y}{a} \sin \frac{2\pi z}{a}$ (d) $\psi = \left(\frac{2}{a}\right)^{3/2} \sin \frac{\pi x}{a} \sin \frac{2\pi y}{a} \sin \frac{3\pi z}{a}$

Ans.: (d)

Solution: $E_{n_x, n_y, n_z} = (n_x^2 + n_y^2 + n_z^2) \frac{\pi^2 \hbar^2}{2ma^2} = \frac{14\pi^2 \hbar^2}{2ma^2}$

$\Rightarrow n_x^2 + n_y^2 + n_z^2 = 14 \Rightarrow n_x = 1, n_y = 2, n_z = 3.$

Note:

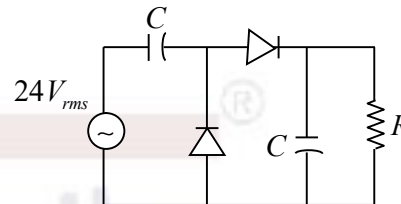
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Test Your fiziks concepts!**Topic: Electronics****(For IIT-JAM, JEST, TIFR and CUET Aspirants)**

Q. In the following circuit, the time constant RC is much greater than the period of the input signal. Assume diode as ideal and resistance R to be large. The dc output voltage across resistance R will be

- (a) $48V$
- (b) $52V$
- (c) $58V$
- (d) $68V$



Ans.: (d)

Solution: It's a voltage doubler circuit

$$V_R = 2V_m = 2(\sqrt{2} V_{rms}) = 2(\sqrt{2} \times 24) \Rightarrow V_R \approx 68 V$$

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Test Your fiziks concepts!**Topic: Modern Physics****(For PGT: KVS, NVS, DSSSB, State Education Boards, etc.)**

Q. A particle is in a state which is a superposition of the ground state φ_0 and the first excited state φ_1 of a one-dimensional quantum harmonic oscillator. The state is given by

$\Phi = \frac{1}{\sqrt{5}}\varphi_0 + \frac{2}{\sqrt{5}}\varphi_1$. The expectation value of the energy of the particle in this state (in units of $\hbar\omega$, ω being the frequency of the oscillator) is

(a) 1.2

(b) 1.3

(c) 1.4

(d) 1.5

Ans.: (b)

Solution.: $\because E_n = \left(n + \frac{1}{2}\right)\hbar\omega$ and $P\left(\frac{\hbar\omega}{2}\right) = \frac{1}{5}$, $P\left(\frac{3\hbar\omega}{2}\right) = \frac{4}{5}$

$$\Rightarrow \langle E \rangle = \frac{\hbar\omega}{2} \times \frac{1}{5} + \frac{3\hbar\omega}{2} \times \frac{4}{5} = \frac{13\hbar\omega}{10} = 1.3\hbar\omega$$

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