Test Your fiziks concepts!

Topic: Quantum Mechanics

(For CSIR NET-JRF, GATE, JEST and TIFR Aspirants)

Q. The state of a particle of mass m in a one dimensional rigid box in the interval 0 to L is given by the normalized wavefunction $\psi(x)=\sqrt{\frac{2}{L}}\left(\frac{3}{5}\sin\left(\frac{2\pi x}{L}\right)+\frac{4}{5}\sin\left(\frac{4\pi x}{L}\right)\right)$. If its energy is measured the possible outcomes and the average value of energy are, respectively

(a) $\frac{h^2}{2mL^2},\frac{2h^2}{mL^2}$ and $\frac{73}{50}\frac{h^2}{mL^2}$

(b) $\frac{h^2}{8mL^2},\frac{h^2}{2mL^2}$ and $\frac{19}{40}\frac{h^2}{mL^2}$

(c) $\frac{h^2}{2mL^2},\frac{2h^2}{mL^2}$ and $\frac{19}{10}\frac{h^2}{mL^2}$

(d) $\frac{h^2}{8mL^2},\frac{2h^2}{mL^2}$ and $\frac{73}{200}\frac{h^2}{mL^2}$

Ans.: (a)

Solution: $\psi(x)=\sqrt{\frac{2}{L}}\left(\frac{3}{5}\sin\left(\frac{2\pi x}{L}\right)+\frac{4}{5}\sin\left(\frac{4\pi x}{L}\right)\right)$

Measurement $E_n=\frac{n^2h^2}{8mL^2}$

$\because n=2\Rightarrow E_2=\frac{2^2h^2}{8mL^2}=\frac{h^2}{2mL^2}$ and $n=4\Rightarrow E_4=\frac{4^2h^2}{8mL^2}=\frac{2h^2}{mL^2}$

Probability $P(E_2)=\frac{9}{25}$ and $P(E_4)=\frac{16}{25}$

Now, average value of energy is

$$\langle E\rangle=\sum E_nP(E_n)=\frac{9}{25}\times\frac{h^2}{2mL^2}+\frac{16}{25}\times\frac{2h^2}{mL^2}=\frac{73h^2}{50mL^2}$$

Note:

For detailed solutions, visit the *Free Download* section at www.physicsbyfiziks.com

Test Your fiziks concepts!

Topic: Electronics

(For IIT-JAM, JEST, TIFR and CUET Aspirants)

Q. A Germanium diode is operated at a temperature of 27 degree C. The diode terminal voltage is $0.3\ V$ when the forward current is $10\ mA$. What is the forward current (in mA) if the terminal voltage is $0.4\ V$?

(a) 477.3 (b) 577.3 (c) 47.73 (d) 57.73

Ans.: (a)

Solution.: $I = I_0\left(e^{V/V_T} - 1\right) \approx I_0 e^{V/V_T}$ where $V_T = \frac{kT}{e} = 0.026V$

$\Rightarrow 10\,mA = I_0 e^{0.3/0.026} = I_0 e^{11.54} \Rightarrow I_0 = \frac{10}{102744}mA$

Thus, $I = I_0 e^{0.4/0.026} = \frac{10}{102744} \times 4876800\ mA \approx 474.6\ mA$

Note:

For detailed solutions, visit the *Free Download* section at www.physicsbyfiziks.com

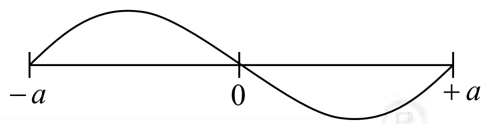
H.No. 40-D, G.F., Jia Sarai, Near IIT, Hauz Khas, New Delhi-16
Phone: 011-26865455/+91-9871145498, Website: www.physicsbyfiziks.com, Email: fiziks.physics@gmail.com

Test Your fiziks concepts!

Topic: Modern Physics

(For PGT: KVS, NVS, DSSSB, State Education Boards, etc.)

Q. A particle is confined in a one-dimensional box with impenetrable walls at $x = \pm a$. Its energy eigenvalue is $2\,eV$ and the corresponding eigenfunction is as shown below.



The lowest possible energy of the particle is

(a) $4\,eV$ (b) $2\,eV$ (c) $1\,eV$ (d) $0.5\,eV$

Ans.: (d)

Solution.: The given state is representation of first exited state whose energy is $2\,eV$.

If E_n is energy of n^{th} state and E_0 is energy of ground state then, $E_n = n^2 E_0$.

So, $E_2 = 4E_0 = 2eV \Rightarrow E_0 = 0.5eV$

Note:

For detailed solutions, visit the *Free Download* section at www.physicsbyfiziks.com

Test Your fiziks concepts!

Topic: Quantum Mechanics

(For CSIR NET-JRF, GATE, JEST and TIFR Aspirants)

Q. The energy eigenvalues of a particle in the potential $V(x)=\frac{1}{2}m\omega^2x^2-ax$ are

(a) $E_n=\left(n+\frac{1}{2}\right)\hbar\omega-\frac{a^2}{2m\omega^2}$

(b) $E_n=\left(n+\frac{1}{2}\right)\hbar\omega+\frac{a^2}{2m\omega^2}$

(c) $E_n=\left(n+\frac{1}{2}\right)\hbar\omega-\frac{a^2}{m\omega^2}$

(d) $E_n=\left(n+\frac{1}{2}\right)\hbar\omega$

Ans.: (a)

Solution.: Hamiltonian (H) of Harmonic oscillator, $H=\frac{p_x^2}{2m}+\frac{1}{2}m\omega^2x^2$

Eigenvalue of this, $E_n=\left(n+\frac{1}{2}\right)\hbar\omega$

But here, $H=\frac{p_x^2}{2m}+\frac{1}{2}m\omega^2x^2-ax\Rightarrow H=\frac{p_x^2}{2m}+\frac{1}{2}m\omega^2\left[x^2-\frac{2ax}{m\omega^2}+\frac{a^2}{m^2\omega^4}\right]-\frac{a^2}{2m\omega^2}$

$$H=\frac{p_x^2}{2m}+\frac{1}{2}m\omega^2\left[x-\frac{a}{m\omega^2}\right]^2-\frac{a^2}{2m\omega^2}$$

Energy eigenvalue, $E_n=\left(n+\frac{1}{2}\right)\hbar\omega-\frac{a^2}{2m\omega^2}$

Note:

For detailed solutions, visit the *Free Download* section at www.physicsbyfiziks.com

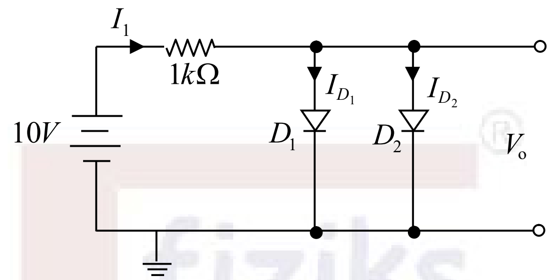
H.No. 40-D, G.F., Jia Sarai, Near IIT, Hauz Khas, New Delhi-16
Phone: 011-26865455/+91-9871145498, Website: www.physicsbyfiziks.com, Email: fiziks.physics@gmail.com

Test Your fiziks concepts!

Topic: Electronics

(For IIT-JAM, JEST, TIFR and CUET Aspirants)

Q. In the circuit below, D_1 and D_2 are two silicon diodes with the same characteristics. If the forward voltage drop of a silicon diode is $0.7\ V$ then the value of the current $I_1 + I_{D_1}$ is



(a) 18.6 mA (b) 9.3 mA (c) 13.95 mA (d) 14.65 mA

Ans.: (c)

Solution.: $I_1 = \dfrac{10-0.7}{1k\Omega} = 9.3\,mA$

$$I_{D_1} = I_{D_2} = \frac{I_1}{2} \Rightarrow \left(I_1 + I_{D_1}\right) = I_1 + \frac{I_1}{2} = \frac{3}{2} I_1 = 13.95\ mA$$

Note:

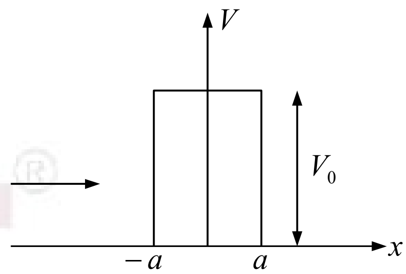
For detailed solutions, visit the *Free Download* section at www.physicsbyfiziks.com

Test Your fiziks concepts!

Topic: Modern Physics

(For PGT: KVS, NVS, DSSSB, State Education Boards, etc.)

Q. Electrons of energy E coming from $x = -\infty$ impinge upon a potential barrier of width $2a$ and height V_0 centered at the origin with $V_0 > E$, as shown in the figure below. Let $k = \frac{\sqrt{2m(V_0 - E)}}{\hbar}$. In the region $-a \le x \le a$, the electrons is a linear combination of



(a) e^{kx} and e^{-kx}

(b) e^{ikx} and e^{-kx}

(c) e^{ikx} and e^{-ikx}

(d) e^{ikx} and e^{kx}

Ans.: (a)

Solution.: Since, $V_0 > E$ in region $-a \le x \le a$. Thus, Schrodinger equation is given by

$$-\frac{\hbar^2}{2m}\frac{\partial^2 \psi}{\partial x^2} + V_o \psi = E\psi \Rightarrow \frac{\partial^2 \psi}{\partial x^2} - \frac{2m(V_o - E)}{\hbar^2}\psi = 0$$

$\Rightarrow \frac{\partial^2 \psi}{\partial x^2} - k^2 \psi = 0$ where $k = \frac{\sqrt{2m(V_0 - E)}}{\hbar}$. So ψ is a linear combination of e^{ikx} and e^{-ikx}.

Thus, the solution of the wave equation is e^{kx} and e^{-kx}, which is exponential in nature.

Note:

For detailed solutions, visit the *Free Download* section at www.physicsbyfiziks.com

H.No. 40-D, G.F., Jia Sarai, Near IIT, Hauz Khas, New Delhi-16
Phone: 011-26865455/+91-9871145498, Website: www.physicsbyfiziks.com, Email: fiziks.physics@gmail.com