PC2232: Physics for Electrical Engineers

Tutorial 6&7 Answers

1. (a) $E = \dfrac{(2n)^2 h^2}{8mL^2}$

   (b) $E = \dfrac{(2n-1)^2 h^2}{8mL^2}$

   (c) (a) and (b) together give us E in lecture notes.

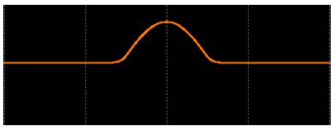
   (d) $\sin \Rightarrow$ odd, $\cos \Rightarrow$ even

2. (a) 6 bound states.

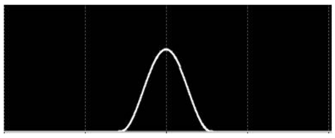
$E_1 = 0.30\text{eV}$	$E_2 = 1.19\text{eV}$	$E_3 = 2.67\text{eV}$
$E_4 = 4.69\text{eV}$	$E_5 = 7.19\text{eV}$	$E_6 = 9.81\text{eV}$

   (b) In classically forbidden regions:
   - There is a small probability that the particle can be in classically forbidden region
   - The higher the energy state of the particle, the higher that probability will be.

   I took the following from the applet itself.

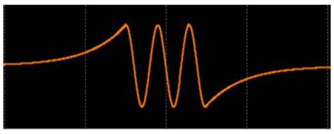


(a) $\psi(x)$

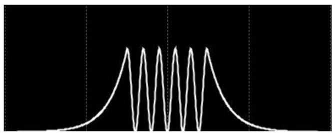


(b) $|\psi(x)|^2$

Figure 1: Lowest Energy Level



(c) $\psi(x)$



(d) $|\psi(x)|^2$

Figure 2: Highest Energy Level

   Important points that must be in you wavefunction and probability density drawing:
   - It goes into the classically forbidden region (but only a bit)
   - It can be seen that for higher n states, it penetrates more into the classically forbidden region

   (c) $E = \dfrac{n^2 h^2}{8mL^2}$

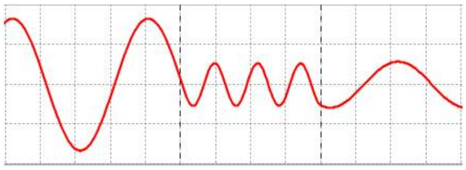
   Infinite square well's energy is higher than the finite square well.

$E_1 = 0.38\text{eV}$	$E_2 = 1.51\text{eV}$	$E_3 = 3.39\text{eV}$
$E_4 = 6.03\text{eV}$	$E_5 = 9.42\text{eV}$	$E_6 = 13.6\text{eV}$

   (d) If width is reduced,
   - Energy for each bound state increases
   - Number of bound states n decreases

   Minimum $L \approx 1.9\text{nm}$

(e) Wavefuction for the case where: $E = 1.0\text{eV}$, $U_0 = 0.9\text{eV}$ and $L = 4.0\text{nm}$.



Important points that must be in you wavefunction drawing:

- Wavelength inside the well is smaller than the wavelength outside the well
  Wavelength outside the well is the same on the left and the right
- Amplitude on the left (before the well) is higher.
- From calculation of infinite square well's energy, you can somewhat guess that there should be $n \approx 6$ or 7 in the well.

3. (b) $A_1 = \left[\frac{2\alpha^3}{\sqrt{\pi}}\right]^{\frac{1}{2}}$

4. $E_b > E_e > E_c > E_a > E_d > E_f$

5. (b) $E = \frac{\hbar^2}{mL^2}$

   (c) The graphs will look like:

(a) $\psi(x)$ (b) $|\psi(x)|^2$

   (d) $A = \sqrt{\frac{15}{16L}}$

   (e) $\int_{-\frac{L}{3}}^{\frac{L}{3}} |\psi(x)|^2 \mathrm{d}x = 0.58$

6. (a) Particles lose potential, drops lower, and gain kinetic energy.
   It will never be found on the left of the origin

   (b) Wavefunctions are:

$$\psi_{\text{I}}(x) = e^{ik_{\text{I}}x} - \frac{1}{3}e^{-ik_I x} \qquad \psi_{\text{II}}(x) = \frac{2}{3}e^{2ik_{\text{I}}x}$$

   where $k_{\text{I}} = \frac{\sqrt{2mE}}{\hbar}$

   (c) $R = \frac{1}{9}$