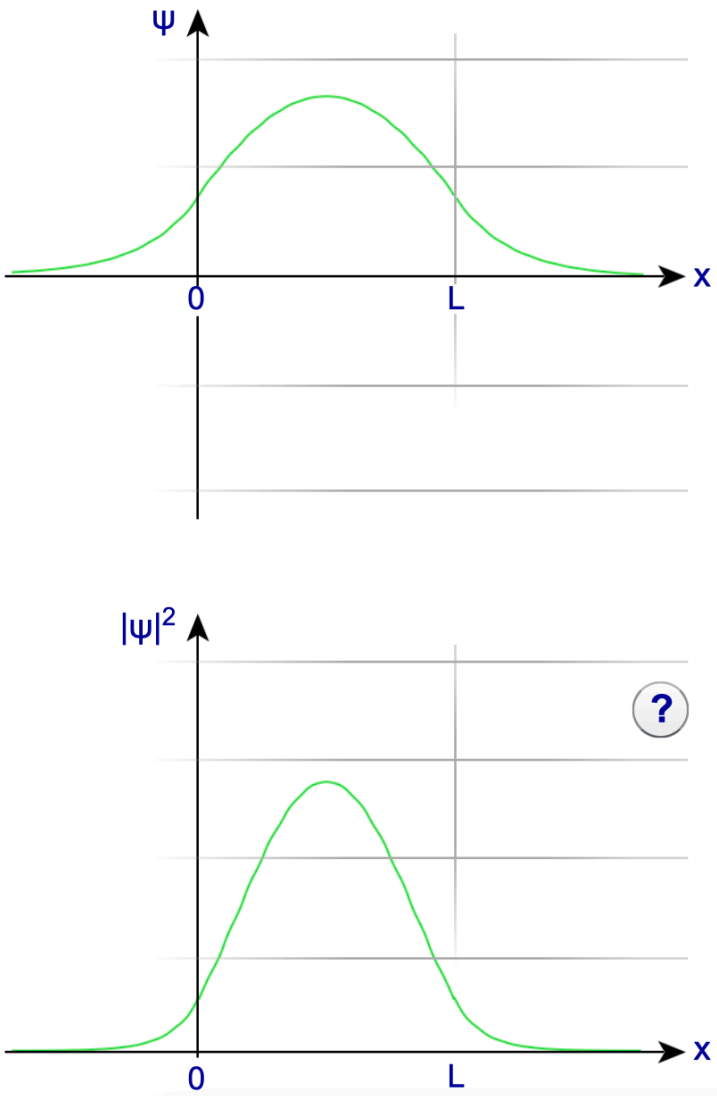
Simulation available at: https://www.st-andrews.ac.uk/physics/quvis/simulations_html5/sims/finite-infinite-well/finite-infinite-well.html

Simulation | Challenges

QuVis

Comparison of the finite and infinite square wells



The graphs show you the ground state and first few excited state wavefunctions and probability densities for a one-dimensional finite well and an infinite well. **How does the well depth effect the shape of the probability density, the number of energy levels and the energy values?** Use the "?" buttons for more information. Then try the Challenges!

Main Controls

Well depth V

V_0 $2V_0$ $3V_0$ $4V_0$ infinite

Ground state | 1st excited state | 2nd excited state | 3rd excited state

☐ Show energy

☐ Show fraction of probabilty density beyond edges of well

For these questions, use the simulation "Comparison of the finite and infinite square wells" in the QuVis HTML5 collection.
https://www.st-andrews.ac.uk/physics/quvis/simulations_html5/sims/finite-infinite-well/finite-infinite-well.html

1) Use the simulation to complete the following table for the **first excited state ψ_2 for different well depths**. Make all your sketches the same scale.

Well depth	Sketch of the 1st excited state probability density $\lvert\psi_2\rvert^2$	Fraction of $\lvert\psi_2\rvert^2$ beyond the well edges	Probability of finding the particle inside the well	First excited state energy E_2	$V - E$ (well depth minus energy)	$\sqrt{V-E}$
V_0						
$2V_0$						
$3V_0$						
$4V_0$						
infinite						

2) Using your data in the table from question 1, construct a graph of the fraction of the probability density $|\psi_2|^2$ beyond the edges of the well versus $\sqrt{V-E}$. Label your axes.

3) Using ideas of de Broglie wavelength, explain qualitatively how the fraction of $|\psi_2|^2$ beyond the edges of the well and the energy E_2 in the question 1 table are related. No quantitative analysis is needed.

4) For the finite well, the form of the **probability density beyond the edges of the well** is an exponential decay similar to the function

$$|\psi(x)|^2 = Ne^{-qx}$$

assuming positive x, where N is a constant and

$$q = \sqrt{\frac{8m}{\hbar^2}(V-E)}$$

with m as particle mass, V as well depth and E as particle energy.

a) For what values of x does the wavefunction decay exponentially for the finite-depth well shown in the simulation?

b) Consider the function e^{-qx} for positive x.
If q is increased, does the function e^{-qx} remain *unchanged*, become *less steep* (fall off to zero more slowly) or become *steeper* (fall off to zero more quickly)?

c) What does an increase of q correspond to in your data from question 1?

d) Using these results, explain qualitatively your graph from question 2 of the fraction of the probability density $|\psi_2|^2$ beyond the edges of the well versus $\sqrt{V-E}$.

e) Using the above expression for q, explain what happens to the fraction of the probability density beyond the edges of the well in the limit of infinite well depth.