For these questions, use the simulation "Fermions and bosons in a one-dimensional infinite square well" in the QuVis HTML5 collection.
https://www.st-andrews.ac.uk/physics/quvis/simulations_html5/sims/FermionsBosons/FermionsBosons.html

1) What does it mean for two particles to be *indistinguishable*?
What are *fermions*, what are *bosons*?
Why are the graphs shown in the simulation two-dimensional, even though the particles are in a one-dimensional well?

2) Choose two **different energy levels** for the two particles.

a) What does the button "swap particles" do?

For parts b) to d), consider the case where the particles are in the ground state and 2nd excited state respectively.

b) Write down explicit expression for the spatial part of the **energy eigenfunction** $\boldsymbol{\psi(x_1, x_2)}$, where x_1 and x_2 are the spatial coordinates of particles 1 and 2 respectively, for the three different types of particles shown in the simulation.

c) Using your expressions from part b), what happens to the energy eigenfunction graph when you swap the two particles for the three different types of particles?

d) Explain how you can see your result from part c) in the simulation graphs.

3) Choose two **different energy levels** for the two particles.

a) From the graphs shown, what happens to the **probability density** $\boldsymbol{|\psi(x_1, x_2)|^2}$ **graph** when you swap the two particles? Complete the table below for the three types of particles shown.

Case	Effect of swapping the particles on the probability density
Distinguishable particles	
Indistinguishable fermions with parallel spins	
Indistinguishable spinless bosons	

For parts b) to d), consider the case where the particles are in the ground state and 2nd excited state respectively.

b) Write down explicit expression for **the probability density** $|\psi(x_1, x_2)|^2$ for the three different types of particles shown in the simulation. Explain your result from part a) using these expressions.

c) What is the physical meaning of the dashed line $x_1 = x_2$ shown?

d) From your expressions for the probability density in part b), determine the probability density for finding both particles *at the same location* for the three types of particles.
Explain how you can see these results in the simulation graphs.

4) Choose the **same energy level** for the two particles. For what particles is this configuration not possible? Explain why this is the case.