First of all this is based on the book Using Mathematica for quantum mechanics by Roman Schmied, this is simply exercise 2.2

Q2.2 The eigenstate basis for the description of the infinite square well of unit width is made up of the ortho-normalized functions

$$\langle x|n\rangle = \phi_n(x) = \sqrt{2}\sin(n\pi x) \tag{2.9}$$

defined on the interval [0, 1], with $n \in \{1, 2, 3, \ldots\}$.

1. Calculate the function $P_\infty(x, y) = \langle x| \left[\sum_{n=1}^{\infty} |n\rangle\langle n|\right] |y\rangle$.
2. In computer-based calculations we limit the basis set to $n \in \{1, 2, 3, \ldots, n_{\max}\}$ for some large value of $n_{\max}$. Using Mathematica, calculate the function $P_{n_{\max}}(x, y) = \langle x| \left[\sum_{n=1}^{n_{\max}} |n\rangle\langle n|\right] |y\rangle$ (use the `Sum` function). Make a plot for $n_{\max} = 10$ (use the `DensityPlot` function).
3. What does the function P represent?

1.For the First part we know that the ϕ_n form a complete orthonormal basis therefore $\sum_{n=1}^{\infty} \left|n\right\rangle \left\langle n\right| = 1$, so we end up with P_∞(x,y)=$\langle x | y \rangle$=δ(x-y)

2. So with finite n, we could simply use $P_{n_{max}}$(x,y)=$\sum_{n=1}^{n_{max}} \langle x | n \rangle \langle n | y \rangle = 2 \sum_{n=1}^{n_{max}}$ Sin(n πx) Sin(n πy) our variable for n_{max} will be m

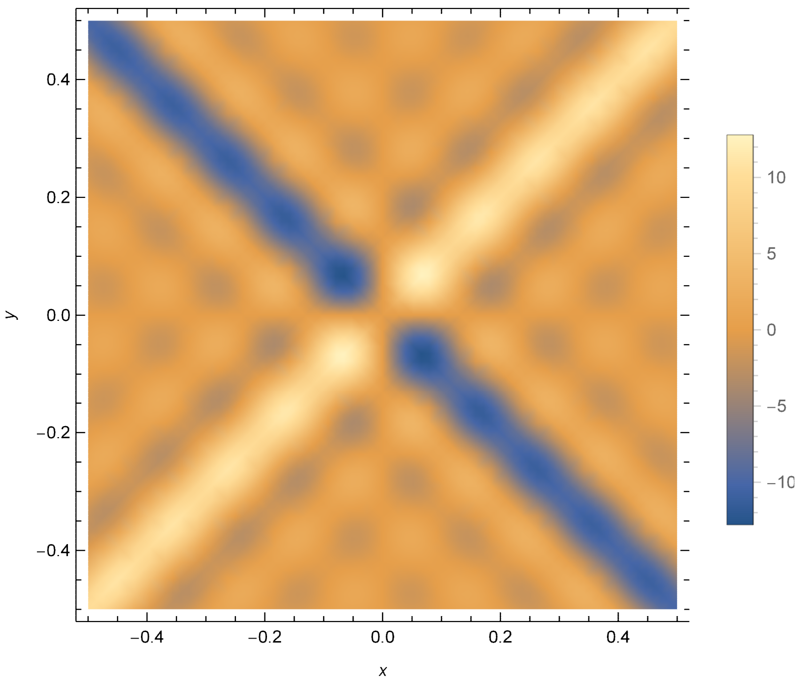
```
In[ ]:= m = 10
Out[ ]= 10

In[ ]:= 10
Out[ ]= 10

In[ ]:= P[x_, y_] = 2 * Sum[Sin[n * π * x] * Sin[n * π * y], {n, m}];
```

In[ ]:=
```
DensityPlot[P[x, y], {x, -0.5, 0.5}, {y, -0.5, 0.5}, PlotRange → All,
  PlotPoints → 2 * m, FrameLabel → {x, y}, PlotLegends → Automatic]
```

Out[ ]=



3. The function $\Pi=\sum_{n=1}^{\infty}|n\rangle\langle n|$ is the proyector onto the computational subspace, and P is it’s representation in coordinate space, when we truncate it , we leave it with finite spatial resolution