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Homework 2

3.

$$\begin{aligned} & \bullet \quad |1\rangle\langle 0| \\ &= \begin{pmatrix} 0 \\ 1 \end{pmatrix} \cdot (1^* \quad 0^*) \\ &= \begin{pmatrix} 0(1^*) & 0(0) \\ 1(1^*) & 1(0) \end{pmatrix} \\ &= \begin{pmatrix} 0 & 0 \\ 1 & 0 \end{pmatrix} \end{aligned}$$

$$\begin{aligned} & \bullet \quad \langle 1|1\rangle \\ &= (0^* \quad 1^*) \cdot \begin{pmatrix} 0 \\ 1 \end{pmatrix} \\ &= 0^*(0) + 1^*(1) \\ &= 1 \end{aligned}$$

$$\begin{aligned} & \bullet \quad |1\rangle \otimes |1\rangle \\ &= \begin{pmatrix} 0 \\ 1 \end{pmatrix} \otimes \begin{pmatrix} 0 \\ 1 \end{pmatrix} \\ &= \begin{pmatrix} 0 \begin{pmatrix} 0 \\ 1 \end{pmatrix} \\ 1 \begin{pmatrix} 0 \\ 1 \end{pmatrix} \end{pmatrix} \\ &= \begin{pmatrix} 0 \\ 0 \\ 0 \\ 1 \end{pmatrix} \end{aligned}$$

$$\begin{aligned} & \bullet \quad \langle 1|H|0\rangle \\ &= (0^* \quad 1^*) \cdot \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & \frac{-1}{\sqrt{2}} \end{pmatrix} \begin{pmatrix} 1 \\ 0 \end{pmatrix} \\ &= (0^* \quad 1^*) \cdot \begin{pmatrix} \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} \end{pmatrix} \\ &= 0^* \left(\frac{1}{\sqrt{2}} \right) + 1^* \left(\frac{1}{\sqrt{2}} \right) \\ &= \frac{1}{\sqrt{2}} \end{aligned}$$

$$\bullet \quad \mathbb{Z} \otimes \mathbb{H}$$

$$\begin{aligned}
 &= \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} \otimes \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & \frac{-1}{\sqrt{2}} \end{pmatrix} \\
 &= \begin{pmatrix} 1 \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & \frac{-1}{\sqrt{2}} \end{pmatrix} & 0 \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & \frac{-1}{\sqrt{2}} \end{pmatrix} \\ 0 \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & \frac{-1}{\sqrt{2}} \end{pmatrix} & -1 \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & \frac{-1}{\sqrt{2}} \end{pmatrix} \end{pmatrix} \\
 &= \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 & 0 \\ \frac{1}{\sqrt{2}} & \frac{-1}{\sqrt{2}} & 0 & 0 \\ 0 & 0 & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ 0 & 0 & \frac{1}{\sqrt{2}} & \frac{-1}{\sqrt{2}} \end{pmatrix}
 \end{aligned}$$