Mathematics Cheat Sheet

1. bra-ket: $\langle u | v \rangle$ = inner product of $|u\rangle$ and $|v\rangle = U^H V$.

2. ket-bra: $|u\rangle \langle v|$ = outer product of $|u\rangle$ and $|v\rangle = UV^H$.

3. ket-ket: $|u\rangle |v\rangle$ = tensor product of $|u\rangle$ and $|v\rangle = |u\rangle \otimes |v\rangle = |uv\rangle = |u, v\rangle$.

4. Outer product is the tensor product of two vectors.

5. Tensor product of two matrices,

$$
A \otimes B = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \otimes \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} = \begin{bmatrix} a_{11} \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} & a_{12} \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} \\ a_{21} \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} & a_{22} \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} \end{bmatrix} \tag{1}
$$

6. Big O: $f(n) = \mathcal{O}(g(n))$

   - $|f|$ is bounded above by g asymptotically, $|f(n)| \leq k \cdot g(n)$ for some positive k.

7. Big Omega: $f(n) = \Omega(g(n))$

   - $|f|$ is bounded below by g asymptotically, $|f(n)| \geq k \cdot g(n)$ for some positive k.

8. Big Theta: $f(n) = \Theta(g(n))$

   - $|f|$ is bounded both above and below by g asymptotically, $k_1 \cdot g(n) \leq |f(n)| \leq k_2 \cdot g(n)$ for some positive k_1, k_2.