> Suppose $V$ is a complex inner product space and $T \in \mathcal{L}(V)$ is a normal operator such that $T^9 = T^8$. Prove that $T$ is self-adjoint and $T^2 = T$.

If $T = 0$, then $0^2 = 0$ and $0$ is self-adjoint. Thus, let $T \neq 0$.

In 7.1, Axler asserts that $V$ is finite-dimensional.

By the complex spectral theorem, $T$ has a diagonal matrix w.r.t. an orthonormal basis of $V$.

Let these entries equal $d_1, \ldots, d_n$. $T^k$ will have on it's diagonal $d_1^k, \ldots, d_n^k$. For each $d_i$, $d_i^8 = d_i^9$. The only values in $\mathbb{F}$ that satisfy this are zero and one; thus every $d_i$ must be a zero or a one.

Thus, $T = T^2$ and $T$ is self-adjoint.

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$$TT^* = T^*T$$

First, we will show that $T^2 = T$. Suppose $T$ is invertible. Then,

$$\begin{aligned} T^9 &= T^8 \\ T^9T^{-7} &= T^8T^{-7} \\ T^2 &= T \end{aligned}$$

Suppose $T$ is not invertible and not equal to zero. Then, $T$ has some zero entries on it's diagonal and some non-zero entries on it's diagonal.