

Step-1

Now consider the following:

$$\begin{aligned} Px &= \left(I - A^T \left(AA^T \right)^{-1} A \right) x \\ &= Ix - A^T \left(AA^T \right)^{-1} Ax \\ &= x - A^T \left(AA^T \right)^{-1} 0 \\ &= x \end{aligned}$$

Step-2

Thus, we have shown that when x is in the nullspace of A , $\boxed{Px = x}$.