Step-1

We have the projection matrix P upon to a line a is $P = \frac{a^T a}{a^T a}$

$$P^2 = \left(\frac{aa^T}{a^T a}\right)\left(\frac{aa^T}{a^T a}\right)$$

$$= \frac{\left(aa^T\right)\left(aa^T\right)}{\left(a^T a\right)\left(a^T a\right)}$$

$$= \frac{a\left(a^T a\right)a^T}{\left(a^T a\right)\left(a^T a\right)}$$

$= \frac{aa^T}{a^T a}$ Since $a^T a$ is a scalar, we cancelled it.

$= P$

Therefore, $\boxed{P^2 = P}$ when P is a projection matrix.