

## Step-1

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

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

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

$$= \frac{aa^T}{a^T a}$$

Since  $a^T a$  is a scalar, we cancelled it.

$$= P$$

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