$$\nabla_\theta J(\theta) = \nabla_\theta \frac{1}{2}(X\theta - y)^T(X\theta - y)$$

$$= \frac{1}{2}\nabla_\theta (\theta^T X^T - y^T)(X\theta - y)$$

$$= \frac{1}{2}\nabla_\theta (\theta^T X^T X\theta - yX^T\theta^T - y^T X\theta + y^T y)$$

$$\Leftarrow \frac{1}{2}\{(ax-b)(ax-b) = a^2x^2 - axb - bax + b^2\}$$

$$= \frac{1}{2}[X^T X\theta + X^T X\theta - X^T y - X^T y]$$

$$= X^T X\theta - X^T y \overset{\text{set}}{=} \vec{0}$$

$$X^T X\theta = X^T y$$

NORMAL EQN

$$\theta = X^T y\,(X^T X)^{-1}$$