2.1

$$f(x) = \frac{1}{2} x^T Q x, \quad df = \frac{1}{2}(dx^T Q x + x^T Q dx) = \frac{1}{2}(x^T Q^T dx + x^T Q dx)$$

$$dx^T Q x = (dx^T Q x)^T = x^T Q^T dx$$

$$\nabla f^T = \frac{1}{2}(x^T Q^T + x^T Q) \Rightarrow \nabla f = \frac{1}{2}(Q x + Q^T x)$$

$$d \nabla f = \frac{1}{2}(Q dx + Q^T dx) = \nabla^2 f \, dx \Rightarrow \nabla^2 f = \frac{1}{2} Q + \frac{1}{2} Q^T$$

$$g_{x,d}(\alpha) = f(x + \alpha \cdot d) = \frac{1}{2}(x^T + \alpha d^T) Q (x + \alpha d) = \frac{1}{2}(x^T Q x + \alpha x^T Q d + \alpha d^T Q x + \alpha^2 d^T Q d)$$

$$g'(\alpha) = \frac{1}{2}(x^T Q d + d^T Q x + 2\alpha d^T Q d) = 0 \Leftrightarrow \alpha = -\frac{x^T Q d + d^T Q x}{2 d^T Q d}$$