

1.2.9

$$p = (2, -3, 1), \quad q = (12, 3, 4)$$

$$|p| = \sqrt{4+9+1} = \sqrt{14}$$

$$|q| = \sqrt{144+9+16} = \sqrt{169}$$

$$p \cdot q = 24 + (-9) + 4 = 19$$

$$\text{proj}(p) = \frac{p \cdot q}{|q|^2} \cdot q = \frac{19}{\sqrt{169}^2} \cdot (12, 3, 4)$$

$$= \left( \frac{228}{169}, \frac{57}{169}, \frac{76}{169} \right)$$

$$\text{perpendicular}(p) = p - \text{proj}(p)$$

$$= (2, -3, 1) - \left( \frac{228}{169}, \frac{57}{169}, \frac{76}{169} \right)$$

$$= \left( \frac{116}{169}, -\frac{564}{169}, \frac{93}{169} \right)$$