

1.2.9

$$P = (2, -3, 1) \text{ , } q = (12, 3, 4)$$

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

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

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

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

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

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

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

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