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① $M = p\mathbf{i} - 6\mathbf{j} - 3\mathbf{k}$, $N = 4\mathbf{i} + 3\mathbf{j} - \mathbf{k}$, $O = \mathbf{i} - 3\mathbf{j} + 2\mathbf{k}$, find the value of P

$$(a) \hat{M} \cdot \hat{N} = (p\mathbf{i} - 6\mathbf{j} - 3\mathbf{k}) \cdot (4\mathbf{i} + 3\mathbf{j} - \mathbf{k})$$

$$= 4p - 18 + 3$$

$$= 4p - 15$$

$$\hat{M} \cdot \hat{N} = 0$$

$$4p - 15 = 0$$

$$4p = 15$$

$$p = \frac{15}{4}$$

$$(b) \hat{M} \cdot (\hat{N} \times \hat{O}) = 0$$

$$N \times O = \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ 4 & 3 & -1 \\ 1 & -3 & 2 \end{vmatrix}$$

$$= \mathbf{i}(6 - (-3)) - \mathbf{j}(8 - (-1)) + \mathbf{k}(-12 - 3)$$

$$= 3\mathbf{i} - 9\mathbf{j} - 15\mathbf{k}$$

$$\hat{M} \cdot (\hat{N} \times \hat{O}) = (p\mathbf{i} - 6\mathbf{j} - 3\mathbf{k}) \cdot (3\mathbf{i} - 9\mathbf{j} - 15\mathbf{k}) =$$

$$= 3p + 54 + 45$$

$$= 3p + 99$$

$$\hat{M} \cdot (\hat{N} \times \hat{O}) = 0$$

$$3p + 99 = 0$$

$$3p = -99$$