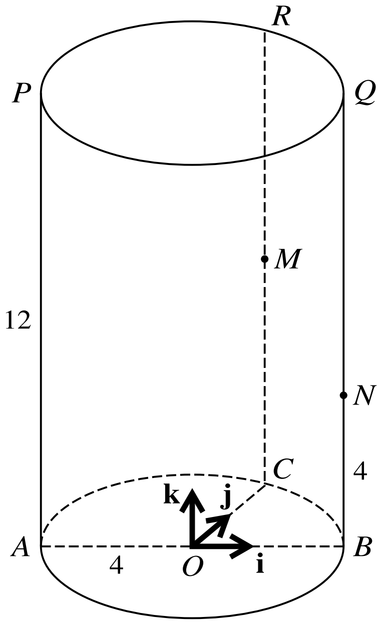
7



The diagram shows a solid cylinder standing on a horizontal circular base with centre O and radius 4 units. Points A, B and C lie on the circumference of the base such that AB is a diameter and angle $BOC = 90°$. Points P, Q and R lie on the upper surface of the cylinder vertically above A, B and C respectively. The height of the cylinder is 12 units. The mid-point of CR is M and N lies on BQ with $BN = 4$ units.

Unit vectors **i** and **j** are parallel to OB and OC respectively and the unit vector **k** is vertically upwards.

Evaluate $\overrightarrow{PN}.\overrightarrow{PM}$ and hence find angle MPN. [7]

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