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## JC MATHEMATICS (H2)

# STUDY TIPS

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## HOW CAN EASILY RECALL LENGTH OF PROJECTION AND PERPENDICULAR DISTANCE UNDER VECTORS

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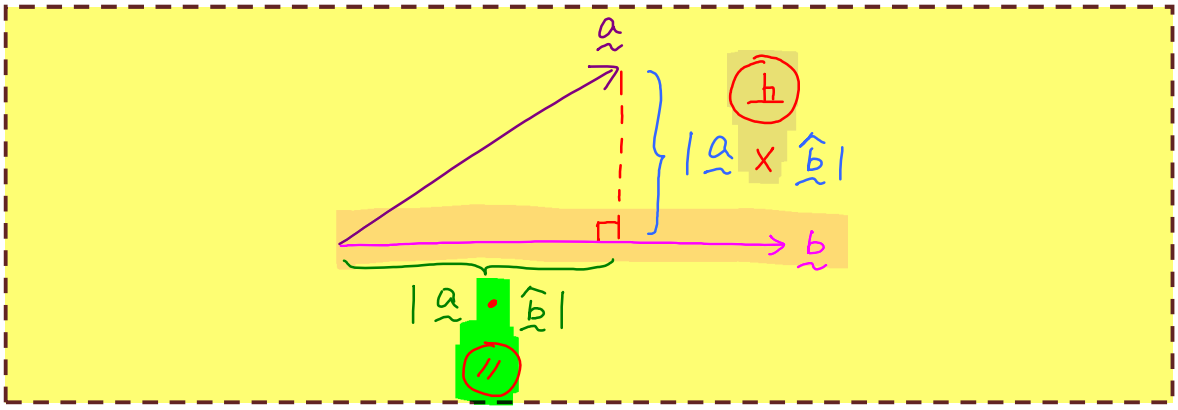
www.h2maths.com

JC_H2Maths_001

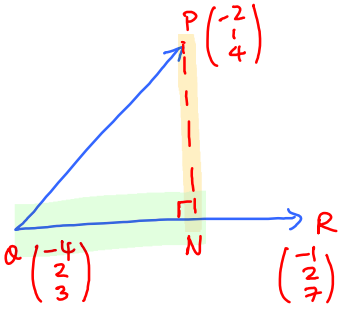
## How to Remember? Dot or Cross?




### *Example 20*

It is given that the points $P$, $Q$ and $R$ have position vectors $-2\mathbf{i}+\mathbf{j}+4\mathbf{k}$, $-4\mathbf{i}+2\mathbf{j}+3\mathbf{k}$ and $-\mathbf{i}+2\mathbf{j}+7\mathbf{k}$ respectively.

(i) Find the length of projection of $PQ$ onto $QR$.




$\overrightarrow{QP} = \begin{pmatrix}-2\\1\\4\end{pmatrix} - \begin{pmatrix}-4\\2\\3\end{pmatrix} = \begin{pmatrix}2\\-1\\1\end{pmatrix}$ $\overrightarrow{QR} = \begin{pmatrix}-1\\2\\7\end{pmatrix} - \begin{pmatrix}-4\\2\\3\end{pmatrix} = \begin{pmatrix}3\\0\\4\end{pmatrix}$

Length of projection of PQ onto QR $= QN = \dfrac{|\overrightarrow{QP}\cdot\overrightarrow{QR}|}{|\overrightarrow{QR}|} = \dfrac{\left|\begin{pmatrix}2\\-1\\1\end{pmatrix}\cdot\begin{pmatrix}3\\0\\4\end{pmatrix}\right|}{\sqrt{3^2+4^2}}$

$= \dfrac{10}{\sqrt{25}} = 2$ units

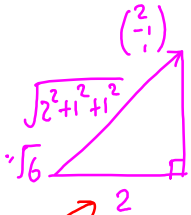
(ii) Find the perpendicular distance from $P$ to $QR$.

$\therefore$ distance from P to QR

$= PN = \dfrac{|\overrightarrow{QP}\times\overrightarrow{QR}|}{|\overrightarrow{QR}|} = \dfrac{\left|\begin{pmatrix}2\\-1\\1\end{pmatrix}\times\begin{pmatrix}3\\0\\4\end{pmatrix}\right|}{\sqrt{3^2+4^2}} = \dfrac{\left|\begin{pmatrix}-4\\-5\\3\end{pmatrix}\right|}{5} = \dfrac{\sqrt{16+25+9}}{5} = \dfrac{\sqrt{50}}{5}$

$= \dfrac{5\sqrt{2}}{5}$

$= \sqrt{2}$ units




OR

$PN^2 = QP^2 - QN^2 = (2^2+1^2+1^2) - 2^2 \Rightarrow PN = \sqrt{6-4} = \sqrt{2}$ units

(i)

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## Explanation

When we break down a vector relative to a directional baseline, we split it into two fundamental components: the part traveling along the path and the part moving away from it.

If you want to find the distance that runs parallel to the direction vector b, you use the dot product. Specifically, taking the absolute value of the dot product with the unit vector, $|a \cdot \hat{b}|$, tells you exactly how much of vector a lies along the direction of b. It gives you the horizontal projection length.

Conversely, if you want to find the distance that is perpendicular to the direction vector b, you use the cross product. The magnitude of the cross product with the unit vector, $|a \times \hat{b}|$, calculates the shortest, straight-line distance away from the baseline. This gives you the vertical height or separation distance.

In short, remember this simple geometric rule: parallel is determined by the dot product, and perpendicular is determined by the cross product

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- **Winner** of International Mathematics Competitions
- **PGDE** Qualification (NIE) with **Distinction in Mathematics**
- Former **School Maths Teacher** in
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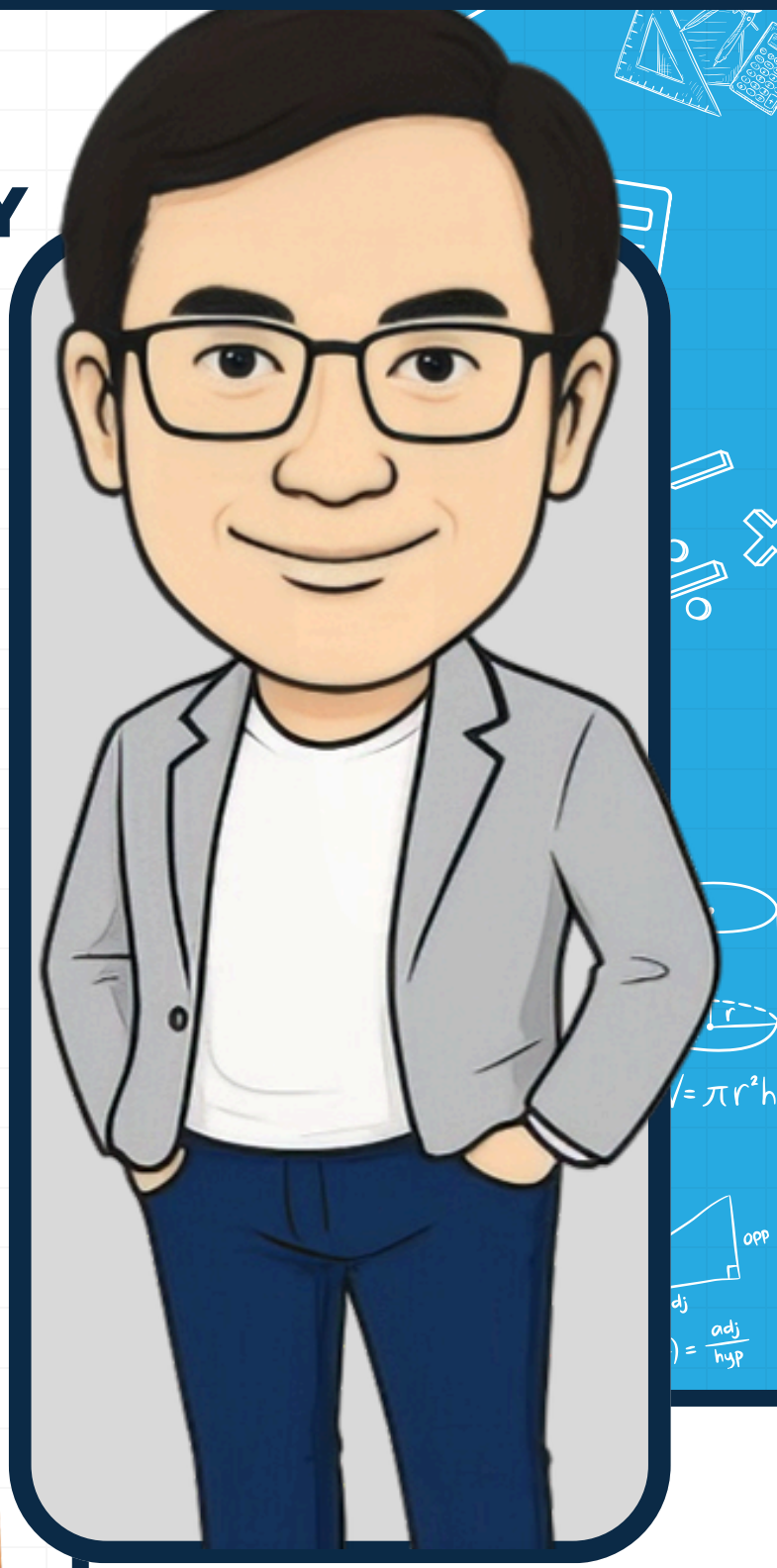
  - Raffles Institution
  - Anglo Chinese School (Indep)



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