

**MX 12**  
**SP b**

A force described by the vector  $\vec{F} = \begin{pmatrix} 2 \\ 1 \end{pmatrix}$  newtons is applied to an object lying on a line  $\ell$  which is parallel to the vector  $\begin{pmatrix} 3 \\ 4 \end{pmatrix}$ .

- (i) Find the component of the force  $\vec{F}$  in the direction of the line  $\ell$ . **2**  
 (ii) What is the component of the force  $\vec{F}$  in the direction perpendicular to the line? **1**

(i) Let  $\vec{v} = \begin{pmatrix} 3 \\ 4 \end{pmatrix}$

$\therefore$  unit vector parallel to  $\vec{v}$  is  $\hat{v}$ .

$$\begin{aligned} \hat{v} &= \frac{\vec{v}}{|\vec{v}|} = \frac{\begin{pmatrix} 3 \\ 4 \end{pmatrix}}{\begin{pmatrix} 3 \\ 4 \end{pmatrix}} \\ &= \frac{\begin{pmatrix} 3 \\ 4 \end{pmatrix}}{\sqrt{3^2 + 4^2}} \\ &= \frac{1}{5} \begin{pmatrix} 3 \\ 4 \end{pmatrix} \\ &= \begin{pmatrix} 0.6 \\ 0.8 \end{pmatrix} \end{aligned}$$

For the projection of  $\vec{F}$  on  $\vec{v}$ :

$$\text{proj}_{\vec{v}} \vec{F} = \frac{\vec{v} \cdot \vec{F}}{|\vec{v}|^2} \hat{v}$$

$$\begin{aligned} \text{Now, } \hat{v} \cdot \vec{F} &= \begin{pmatrix} 0.6 \\ 0.8 \end{pmatrix} \cdot \begin{pmatrix} 2 \\ 1 \end{pmatrix} \\ &= 0.6 \times 2 + 0.8 \times 1 \\ &= 2 \end{aligned}$$

Also,  $|\hat{v}|^2 = \sqrt{0.6^2 + 0.8^2}$

$$= 1$$

$$\begin{aligned} \therefore \text{proj}_{\vec{v}} \vec{F} &= \frac{2}{1} \hat{v} \\ &= 2 \begin{pmatrix} 0.6 \\ 0.8 \end{pmatrix} \\ &= \begin{pmatrix} 1.2 \\ 1.6 \end{pmatrix} \end{aligned}$$

(ii) As  $\vec{F} = \begin{pmatrix} 2 \\ 1 \end{pmatrix}$ , then

$$\begin{pmatrix} 2 \\ 1 \end{pmatrix} - \begin{pmatrix} 1.2 \\ 1.6 \end{pmatrix} = \begin{pmatrix} 0.8 \\ -0.6 \end{pmatrix}.$$

$$[\text{Checking, } \begin{pmatrix} 1.2 \\ 1.6 \end{pmatrix} \cdot \begin{pmatrix} 0.8 \\ -0.6 \end{pmatrix} = 0]$$

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