

## Combining Forces

### Starter

1. (Review of last lesson)

A force of 12 N acts on a particle of mass 60 kg causing the velocity of the particle to increase from 3 m/s to 7 m/s. Find the distance that the particle travels during this period.

**Working:**  $F = ma:$   $12 = 60a$   
 $a = 0.2$   
 $u = 3, v = 7, a = 0.2, s = ?$   
 No  $t \Rightarrow v^2 = u^2 + 2as:$   $7^2 = 3^2 + 2 \times 0.2 \times s$   
 $s = 100$

The particle travels 100 m during this period

2. (Review of last lesson) A particle of mass 10 kg is acted on by a force of  $(8\mathbf{i} - 2\mathbf{j})$  N.

- Find the acceleration of the particle in vector form.
- Find the magnitude of the acceleration.
- Assuming that the particle is initially at rest, find the speed of the particle after 6 seconds.

**Working:** (a)  $\mathbf{F} = m\mathbf{a}: \quad 8\mathbf{i} - 2\mathbf{j} = 10\mathbf{a}$   
 $\mathbf{a} = 0.8\mathbf{i} - 0.2\mathbf{j}$   
 The acceleration of the particle is  $(0.8\mathbf{i} - 0.2\mathbf{j})$  m/s<sup>2</sup>.

(b)  $|\mathbf{a}| = |0.8\mathbf{i} - 0.2\mathbf{j}| = \sqrt{0.8^2 + (-0.2)^2} = 0.825$   
 The magnitude of the acceleration is 0.825 m/s<sup>2</sup>

(c)  $u = 0, a = 0.825, t = 6, v = ?$   
 No  $s \Rightarrow v = u + at:$   $v = 0 + 0.825 \times 6$   
 $v = 4.95$   
 The speed of the particle after 6 seconds is 4.95 m/s

**E.g. 1** An object, being pulled by a 12 N force, experiences a frictional force of 5 N in the opposite direction. What is the resultant force?

**Working:** Resultant force =  $12 - 5 = 7$  N

**E.g. 2** Two forces, given by the vectors  $(3\mathbf{i} - \mathbf{j})$  N and  $(-2\mathbf{i} + 4\mathbf{j})$  N, act on an object. Calculate the resultant force.

**Working:** Resultant force =  $(3\mathbf{i} - \mathbf{j}) + (-2\mathbf{i} + 4\mathbf{j}) = (\mathbf{i} + 3\mathbf{j})$  N

**E.g. 3** A force of 6 N acting west and 10 N acting north acts on a body. Find

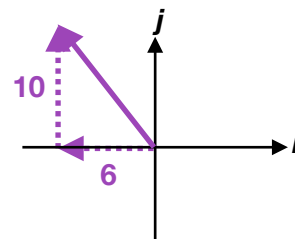
- (a) the magnitude of the resultant force and
- (b) the direction of the resultant force.

**Hint:** draw a diagram with vectors nose to tail.

**Working:** (a) Magnitude =  $\sqrt{6^2 + 10^2} \approx 11.7$  N

- (b) The force acts in the second quadrant.

$$\begin{aligned} \text{Direction} &= 180^\circ - \tan^{-1}\left(\frac{10}{6}\right) \\ &= 121.0^\circ \text{ (4 s.f.)} \end{aligned}$$



**E.g. 4** Find the resultant of the two force  $(8\mathbf{i} + 5\mathbf{j})$  N and  $(3\mathbf{i} - 2\mathbf{j})$  N:

- (a) in component form and
- (b) giving the magnitude and direction of the force.

**Working:** (a) Resultant force =  $(8\mathbf{i} + 5\mathbf{j}) + (3\mathbf{i} - 2\mathbf{j}) = (11\mathbf{i} + 3\mathbf{j})$  N

- (b) Magnitude =  $\sqrt{11^2 + 3^2} \approx 11.4$  N  
The force acts in the first quadrant

$$\text{Direction} = \tan^{-1}\left(\frac{3}{11}\right) = 15.3^\circ$$

**Video:** [Force diagrams](#)

[Solutions to Starter and E.g.s](#)

### Exercise

p486 21B Qu 1i, 2i, 3i, 4i, 5i, 6i, 7-9