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## 9 Displacement and Distance

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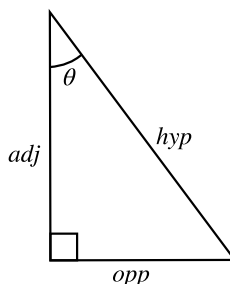
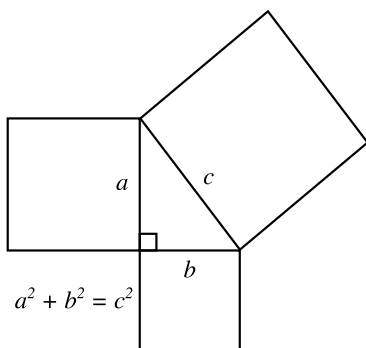
The straight line distance between an object's starting point and its end point - together with the **direction** - is called its **displacement**. The length of the path along which the object moves is the **distance**.

Displacement is a **vector** since it has a direction associated with it. Distance is a **scalar**; see Section 8.

Distance and displacement are both measured in metres (m) in SI units.

If an object moves in a circle, after one complete rotation, the displacement will equal **zero** and the distance travelled will equal the **circumference of the circle**.

If an object is displaced in two perpendicular steps, the magnitude of the displacement can be calculated using **Pythagoras' theorem** and the direction can be calculated using trigonometry.



$$\sin \theta = \frac{\text{distance opposite the angle}}{\text{distance along the hypotenuse}}$$

$$\cos \theta = \frac{\text{distance adjacent to the angle}}{\text{distance along the hypotenuse}}$$

$$\tan \theta = \frac{\text{distance opposite the angle}}{\text{distance adjacent to the angle}}$$

9.1 A bus travels 500 m east, 250 m north, 500 m east and 250 m south.

- What distance has the bus travelled?
- What is the final displacement of the bus?

- 9.2 A climber climbs 50.0 m up a vertical cliff face, before being forced to climb back down 5.00 m so that she can find an alternative route to the top of the cliff. She climbs sideways to the left 10.0 m, then continues to climb 55.0 m to the top.
- (a) What distance has the climber travelled?
  - (b) What is the magnitude (size) of her final displacement measured from her starting point?
- 9.3 An object is displaced by 60.0 m at a bearing of  $60.0^\circ$ . If the object then moved 30.0 m due north, what is the final magnitude of displacement of the object from its origin?
- 9.4 A box is dropped from an aeroplane 2 000 m high travelling horizontally at 100 m/s. The box takes 20.2 s to hit the ground. While the box speeds up vertically, it continues at 100 m/s horizontally.
- (a) What distance has the box travelled horizontally when it hits the ground?
  - (b) When the box hits the ground, what is the magnitude of the displacement of the box from the location it was released? i.e. how far is the box from the release point?
  - (c) What is the angle between the horizontal and the displacement of the box from the location it was released? Give your answer to 3 significant figures.
- 9.5 A bridge is a quarter of a circle of radius 20.0 m.
- (a) What distance does a car travel whilst crossing the bridge?
  - (b) What is its displacement from the start to the end of the bridge?
- 9.6 A car is moving at a speed of 10.0 m/s. It is on a roundabout with a diameter of 50 m. After 23.56 s on the roundabout:
- (a) What distance has the car travelled?
  - (b) How many turns of the roundabout has the car made?
  - (c) What is the magnitude of the car's displacement from where it entered the roundabout?
  - (d) Other than at the very start,  $t = 0$  s, is it possible for the distance the car has traveled to equal its displacement at any point on the roundabout? Explain your answer.