18 | Speed, Distance and Time

18.1 | Speed

In this section we introduce the idea of speed, considering both *instantaneous speed* and *average speed*.

$$\text{Instantaneous speed} \quad = \quad \text{speed at any instant in time}$$

$$\text{Average speed} \quad = \quad \frac{\text{distance travelled}}{\text{time taken}}$$

If a car travels 100 miles in 2 hours,

$$\text{average speed} \quad = \quad \frac{100}{2}$$

$$= \quad 50 \text{ mph}$$

The car does not travel at a constant speed of 50 mph; its speed varies during the journey between 0 mph and, perhaps, 70 mph. The speed at any time is called the *instantaneous speed.*

The following table lists units in common use for speed and their abbreviations:

Distance	Time	Speed	Abbreviation
mile	hours	miles per hour	mph
kilometres	hours	kilometres per hour	km/h
metres	hours	metres per hour	m/h
metres	seconds	metres per second	m/s
feet	seconds	feet per second	f.p.s. *or* ft. per sec.
centimetres	seconds	centimetres per second	cm/sec *or* cm/s

Example 1

Judith drives from Plymouth to Southampton, a distance of 160 miles, in 4 hours.

She then drives from Southampton to London, a distance of 90 miles, in 1 hour and 30 minutes.

Determine her average speed for each journey.

Solution

Plymouth to Southampton Average speed $= \dfrac{160}{4}$

$= 40$ mph

Southampton to London Time taken $= 1$ hour and 30 minutes

$= 1\dfrac{1}{2}$ hours *or* $\dfrac{3}{2}$ hours

Average speed $= 90 \div \dfrac{3}{2}$

$= 90 \times \dfrac{2}{3}$

$= 60$ mph

Example 2

John can type 960 words in 20 minutes.

Calculate his typing speed in:

(a) words per minute,

(b) words per hour.

Solution

(a) Typing speed $= \dfrac{960}{20}$

$= 48$ words per minute

(b) Typing speed $= 48 \times 60$

$= 2880$ words per hour

Exercises

1. Peter drives 320 miles in 8 hours. Calculate his average speed.

2. Daisy drives from Sheffield to London, a distance of 168 miles, in 4 hours.
    Calculate her average speed.

3. A snail moves 8 m in 2 hours. Calculate the average speed of the snail in
    metres per hour.

4. A lorry driver keeps a record of each journey he makes. Calculate the
    average speed for each journey, using the table below:

Start	Finish	Start Time	Finish Time	Distance
Brighton	Norwich	0800	1200	172 miles
Norwich	Carlisle	1400	1900	280 miles
Carlisle	Cardiff	1000	1800	300 miles
Cardiff	Exeter	0700	0930	120 miles
Exeter	Brighton	1030	1530	175 miles

5. Javinda takes $1\frac{1}{2}$ hours to drive 30 km in the rush hour. Calculate his
    average speed in km/h.

6. Rebecca cycles 20 miles on her bike in 2 hours and 30 minutes. Calculate
    her average speed in mph.

7. Julie can type 50 words in 2 minutes.
    Debbie can type 300 words in 15 minutes.

    Calculate the typing speed of each of the girls in:

    (a) words per minute,

    (b) words per hour.

8. Fatima, Emma and Andy each drive from London to Brighton, a distance of

    60 miles. Fatima takes 1 hour, Emma takes 2 hours and Andy takes

    $1\frac{1}{2}$ hours. Calculate the average speed for each of the drivers.

9.   Eva drives from Edinburgh to Dover in 3 stages:

	Start Time	*Finish Time*	*Distance*
Edinburgh to Leeds	0620	0920	210 miles
Leeds to London	1035	1305	200 miles
London to Dover	1503	1703	78 miles

Calculate her average speed for each stage of her journey.

10.   Delia drives 220 km in $3\frac{1}{2}$ hours. Calculate her average speed correct to the nearest km/h.

18.2 Calculating Speed, Distance and Time

In this section we extend the ideas of speed to calculating *distances* and *times*, using the following formulae:

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

$$\text{Distance} = \text{Speed} \times \text{Time}$$

$$\text{Time} = \frac{\text{Distance}}{\text{Speed}}$$

Example 1

Jane drives at an average speed of 45 mph on a journey of 135 miles. How long does the journey take?

Solution

$$\text{Time} = \frac{\text{distance}}{\text{speed}}$$

$$= \frac{135}{45}$$

$$= 3 \text{ hours}$$

Example 2

Chris cycles at an average speed of 8 mph. If he cycles for $6\frac{1}{2}$ hours, how far does he travel?

Solution

Distance $=$ speed $\times$ time

$\qquad = \ 8 \times 6\frac{1}{2}$

$\qquad = \ 52$ miles

Example 3

Nikki has to travel a total of 351 miles. She travels the first 216 miles in 4 hours.

(a) Calculate her average speed for the first part of the journey.

(b) If her average speed remains the same, calculate the total time for the complete journey.

Solution

(a) Average speed $= \dfrac{\text{distance}}{\text{time}}$

$\qquad\qquad\qquad = \dfrac{216}{4}$

$\qquad\qquad\qquad = \ 54$ mph

(b) Time $= \dfrac{\text{distance}}{\text{speed}}$

$\qquad\quad = \dfrac{351}{54}$

$\qquad\quad = \ 6.5$ hours

18.2

Exercises

1. Calculate the distance that you would travel if you drove for:

   (a) 3 hours at 20 mph

   (b) 8 hours at 60 mph

   (c) $\frac{1}{2}$ hour at 76 mph

   (d) $1\frac{1}{2}$ hours at 42 mph

   (e) $6\frac{1}{4}$ hours at 40 mph

   (f) 30 minutes at 33 mph

   (g) 45 minutes at 60 mph

   (h) 90 minutes at 45 mph

2. How long does it take to travel:

   (a) 120 miles at 40 mph

   (b) 300 miles at 50 mph

   (c) 240 miles at 60 mph

   (d) 385 miles at 70 mph

   (e) 60 miles at 40 mph

   (f) 360 miles at 30 mph

   (g) 390 miles at 60 mph

   (h) 253 miles at 46 mph

3. A car travels 300 miles in 5 hours. Calculate the average speed of the car in:

   (a) mph,

   (b) miles per minute.

   How long does it take for the car to travel 82 miles?

4. Janet and Bill leave their home at the same time. Janet has 60 miles to travel and drives at 40 mph. Bill has 80 miles to travel and also drives at 40 mph.

   (a) How long does Janet's journey take?

   (b) How much longer does Bill spend driving than Janet?

5. An athlete can run long distances at 4 metres per second. How far can she run in:

   (a) 50 seconds,

   (b) 3 minutes,

   (c) 1 hour,

   (d) $2\frac{1}{2}$ hours ?

6. Andrew rows at an average speed of 2 metres per second.

   (a) How long does it take him to row:

   (i) 70 m, (ii) 800 m, (iii) $1\frac{1}{2}$ km ?

(b)   How far can Andrew row in:

(i)   12 seconds,   (ii) $3\frac{1}{2}$ minutes,   (iii)   4 hours ?

7.   A snail moves 5 m in 2 hours, If the snail moves at the same speed, calculate:

(a)   the time it takes to move 20 m,

(b)   the distance it would move in $3\frac{1}{2}$ hours,

(c)   the time it takes to moves 1 m,

(d)   the distance that it moves in 15 minutes.

8.   Laura drives for 3 hours at 44 mph.
Clare drives 144 miles in 4 hours.

(a)   Who travels the greater distance?

(b)   Whose speed is the slower?

(c)   How far would Laura travel if she drove for 3 hours at the same speed as Clare?

9.   A lorry travels for 3 hours at 48 mph and then for 2 hours at 53 mph.

(a)   What is the total distance travelled by the lorry?

(b)   What is the average speed for the whole journey?

10.   Sally drives for $2\frac{1}{2}$ hours at 50 mph, then drives 80 miles at 40 mph, and finally drives for 30 minutes at 60 mph.

(a)   Calculate the total distance that Sally drives.

(b)   Calculate the time that Sally takes for the journey.

(c)   Calculate her average speed for the whole journey.

18.3 Problems with Mixed Units

In this section we consider working with mixed units, and with changing units used for speeds.

Example 1

(a)   Convert 1 hour 24 minutes to hours (decimal).

(b)   Write 2.32 hours in hours and minutes.

Solution

(a) $\dfrac{24}{60} = 0.4$

Therefore,

$$1 \text{ hr } 24 \text{ mins } = 1.4 \text{ hours}$$

(b) $0.32 \times 60 = 19.2$

Therefore,

$$2.32 \text{ hours } = 2 \text{ hrs } 19.2 \text{ mins}$$

Example 2

A car travels 200 miles in 3 hours and 20 minutes. Calculate the average speed of the car in mph.

Solution

$$3 \text{ hours } 20 \text{ minutes } = 3\frac{20}{60}$$

$$= 3\frac{1}{3} \text{ hours}$$

$$\text{Speed} = \text{distance} \div \text{time}$$

$$= 200 \div 3\frac{1}{3}$$

$$= 200 \div \frac{10}{3}$$

$$= 200 \times \frac{3}{10}$$

$$= 60 \text{ mph}$$

Example 3

An athlete runs 1500 m in 3 minutes and 12 seconds. Calculate the average speed of the athlete in m/s.

Solution

$$3 \text{ minutes } 12 \text{ seconds } = 3 \times 60 + 12$$

$$= 192 \text{ seconds}$$

Speed $= \dfrac{\text{distance}}{\text{time}}$

$\qquad = \dfrac{1500}{192}$

$\qquad =$ 7.8 m/s to 1 decimal place

Example 4

A bus travels at a speed of 40 km/h. Calculate the speed of the bus in:

(a)   m/s

(b)   mph.

Solution

(a)   1 km = 1000 m

$\qquad$ 40 km/h = 1000×40 m/hr

$\qquad$ 1 hour   = 60×60

$\qquad\qquad\quad =$ 3600 seconds

$\qquad$ 40 km/h $= \dfrac{1000 \times 40}{3600}$

$\qquad\qquad\quad =$ 11.1 m/s to 1 decimal place

(b)   1 km $= \dfrac{5}{8}$ mile

$\qquad$ So 40 km/h $= \dfrac{5}{8} \times 40$

$\qquad\qquad\qquad\quad =$ 25 mph

Example 5

Convert a speed of 8 m/s to mph.

Solution

8 m/s $=$ 8×3600 m/h

$\qquad =$ 28 800 m/h

$\qquad =$ 28.8 km/h

$28.8 \times \dfrac{5}{8}$ $=$ 18 mph

Exercises

1. Convert the following times from hours and minutes to hours, giving your answers as mixed numbers and decimals, correct to 2 decimal places.

   (a)   1 hour 40 minutes   (b)   3 hours 10 minutes

   (c)   1 hour 6 minutes   (d)   2 hours 18 minutes

   (e)   3 hours 5 minutes   (f)   6 hours 2 minutes

   (g)   1 hour 7 minutes   (h)   2 hours 23 minutes

2. Change the following times to hours and minutes:

   (a) $1\frac{1}{4}$ hours   (b)   1.2 hours

   (c)   3.7 hours   (d)   4.4 hours

   (e)   1.45 hours   (f)   3.65 hours

3. A car travels 60 miles in 50 minutes. Calculate the average speed of the car in mph.

4. Jane drives 80 miles in 1 hour and 40 minutes. Calculate her average speed.

5. Convert the following speeds to km/h:

   (a)   60 mph   (b)   43 m/s

   (c)   66 m/s   (d)   84 mph

6. Convert the following speeds to mph:

   (a)   16 m/s   (b)   82 km/h

   (c)   48 km/h   (d)   7 m/s

7. Alec drives 162 km in 2 hours and 12 minutes. Calculate his average speed in:

   (a)   km/h   (b)   m/s   (c)   mph

   Give your answers to 2 decimal places.

8. Jai drives 297 miles in 5 hours and 24 minutes.

   (a)   Calculate his average speed in mph.

   (b)   He then drives for a further 1 hour and 28 minutes at the same average speed. How far has he travelled altogether?

   Give your answers to 2 decimal places.