Chapter 2. Describing motion (kinematics)

Contents:

1.2 Motion

Core

1 Define speed as distance travelled per unit time; recall and use the equation

$$v = \frac{s}{t}$$

2 Define velocity as speed in a given direction

3 Recall and use the equation

$$\text{average speed} = \frac{\text{total distance travelled}}{\text{total time taken}}$$

4 Sketch, plot and interpret distance–time and speed–time graphs

5 Determine, qualitatively, from given data or the shape of a distance–time graph or speed–time graph when an object is:

(a) at rest
(b) moving with constant speed
(c) accelerating
(d) decelerating

6 Calculate speed from the gradient of a straight-line section of a distance–time graph

7 Calculate the area under a speed–time graph to determine the distance travelled for motion with constant speed or constant acceleration

8 State that the acceleration of free fall g for an object near to the surface of the Earth is approximately constant and is approximately $9.8\,\text{m/s}^2$

Supplement

9 Define acceleration as change in velocity per unit time; recall and use the equation

$$a = \frac{\Delta v}{\Delta t}$$

10 Determine from given data or the shape of a speed–time graph when an object is moving with:

(a) constant acceleration
(b) changing acceleration

11 Calculate acceleration from the gradient of a speed–time graph

12 Know that a deceleration is a negative acceleration and use this in calculations

13 Describe the motion of objects falling in a uniform gravitational field with and without air/liquid resistance (including reference to terminal velocity)

2.1 Understanding speed

2.1.1 Measuring speed

Recall what we did in measuring density, what do you think we need to measure in order to get the speed of an object?

speed: average speed vs instantaneous speed

Calculating speed:

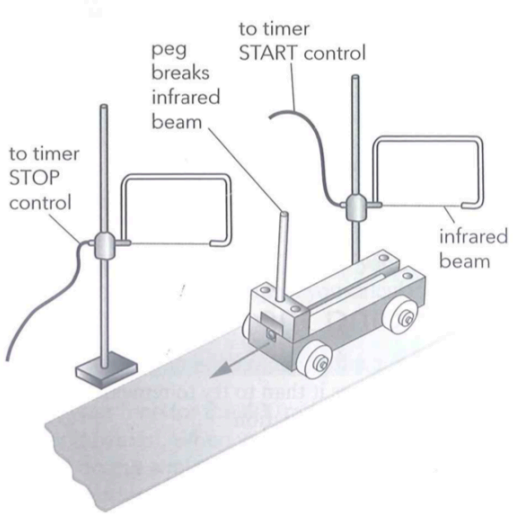
rearranging the equation:

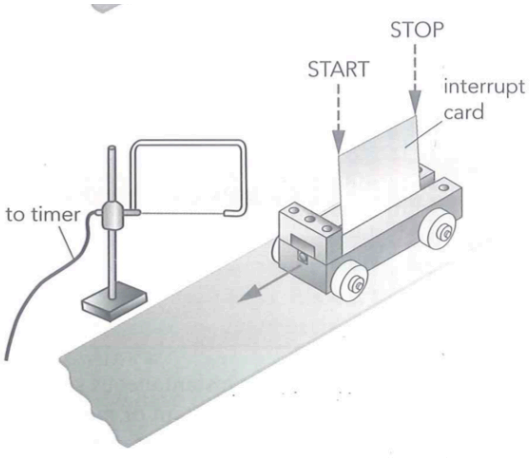
unit of speed:

2.1.2 Experiment: determine speed in the laboratory

Two sets:

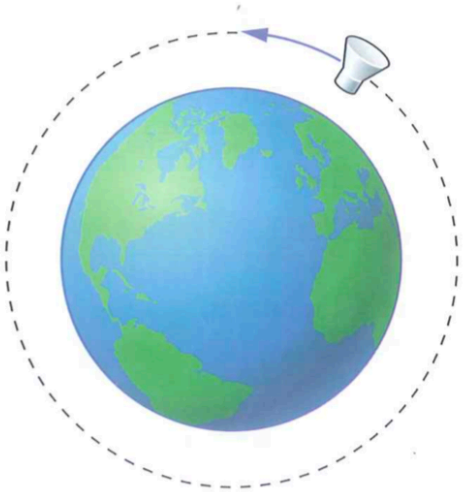
1. Using a peg + two light gates
2. Using a interrupt card + a light gate





Exercise 2.a

A spacecraft is orbiting the Earth at a steady speed of 8km/s. How long does it take to complete a single orbit?



Exercise 2.b

A car travels 600km in 5.5 hours, what is the speed of the car in km/h and m/s?

Exercise 2.c

Calculate how long does it takes for sunlight to reach us from the Sun? The Sun is about 144 million km away and the speed of light is around $3 \times 10^8 \ m/s$.

2.2 Distance-time graphs

Distance-time graphs —> to visually describe how something moves

Can you draw the distance-time graph of a coach according to the description below:
"The coach drove away from the bus stop. It travels at a steady speed along the main road, leaving town. After five minutes, it reached the highway, where it was able to speed up. After them minutes, it was forced to stop because of traffic."

Slope/gradient of distance-time graph:

Larger Slope:

Slope = 0:

Exercise 2.d

The following figure shows the distance-time graph for a woman running a mountain marathon.

How far did she travel?

What was her average speed in km/h?

How many stops did she make?

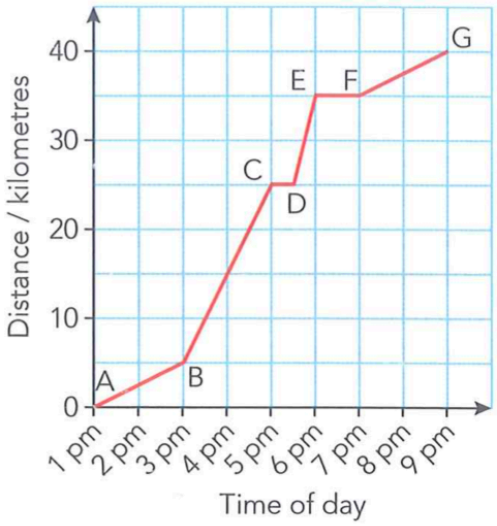
The rules said she had to sop for half an hour for food. When did she take the break?

Later she stopped to help an injured runner. When did this happen?

What would her average speed have been ion she had not stopped at all?

What was her highest speed and over what section

did this happen?



2.3 Understanding acceleration

2.3.1 What information do you get from a common car advert — “from 0 to 100km/h in 5s”?

Acceleration: speed increase

Deceleration: speed decrease

2.3.2 vectors vs scalars

Speed vs Velocity:

Scalar vs vector:

Exercise 2.e

Which of the following physical quantities are scalars? Which are vectors?
distance, speed, time, mass, energy, force, weight, velocity, acceleration, momentum, electric field strength, gravitational field strength

Vector addition:

Exercise 2.f

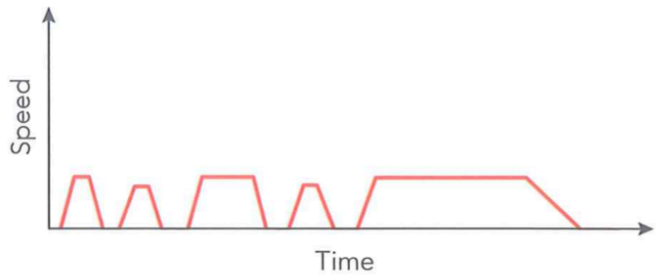
An aircraft is flying due north with a velocity of 200 m s−1. A side wind of velocity 50 m s−1 is blowing due east. What is the aircraft's resultant velocity (give the magnitude and direction)?

2.4 speed-time graphs

2.4.1 Recap information we get from distance-time graphs, what information do you expect to get from speed-time graphs?

Attention: always check the axes to see labels when reading graphs!!

The following speed-time graph shows a bus's speed change over a time period. What information can you get from it?



In summary, in speed-time graphs:

Slope:

Larger slope:

Positive slope:

Negative slope:

Slope =0 (a horizontal graph):

Straight line:

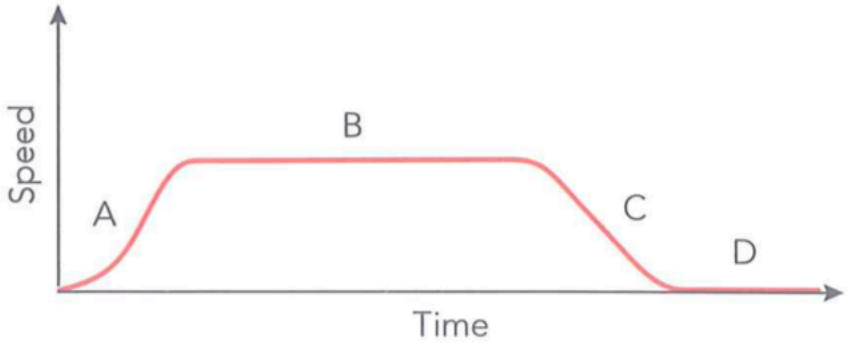
Curved line:

Calculating acceleration:

Unit of acceleration:

Exercise 2.g

Look at the following speed-time graph of a train during part of its journey. Describe the motion of the train in each phase, namely A, B, C, D.



Phase A:

Phase B:

Phase C:

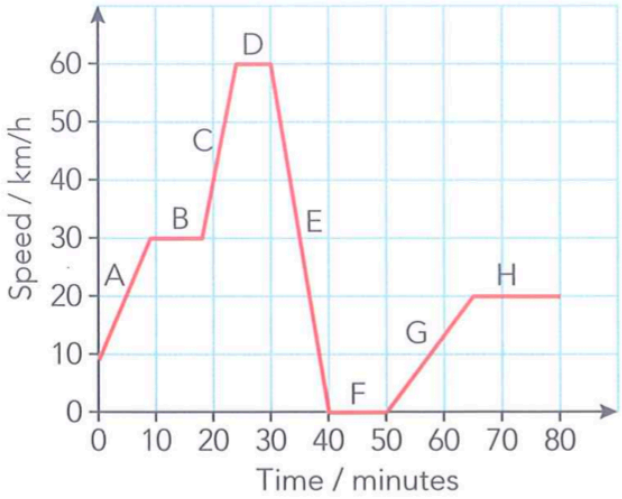
Phase D:

Exercise 2.h

Look at the speed-time graph on the right.

Name the sections that represent:

a. steady speed
b. speeding up (accelerating)
c. being stationary
d. slowing down (decelerating)

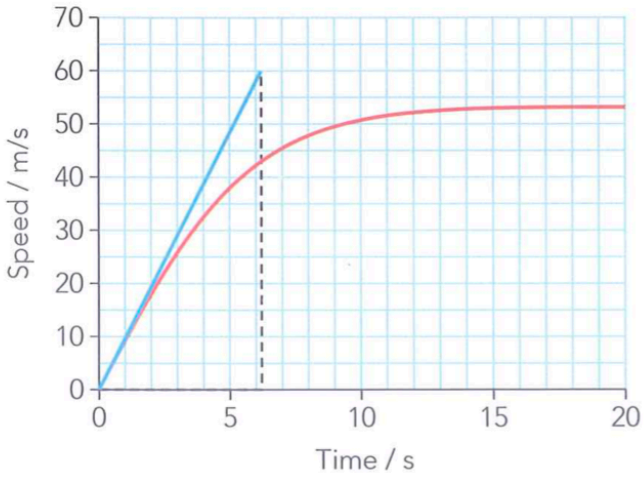


Exercise 2.i

During an aircraft's landing, its speed changes from 300m/s to 50m/s in 80s. What is its acceleration?

Exercise 2.j

What is the skydiver's acceleration at a. 0s, b 5.5s



2.4.2 Finding distance travelled

Speed-time graph tells us how speed changes. Can we know distance from it? Why?

distance =

Calculating distance from speed-time graph(calculating area):

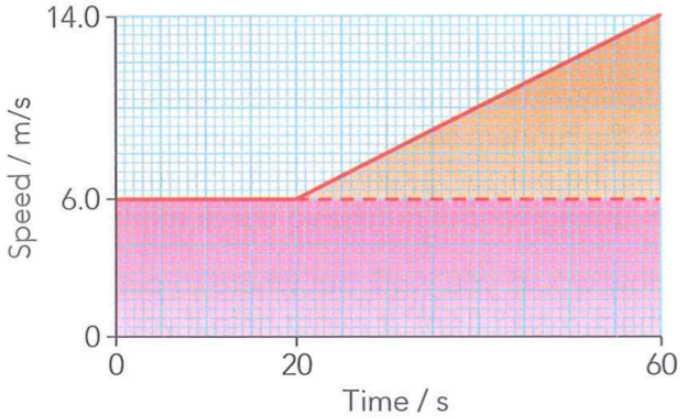
Straight-line graph can be broken down into rectangles and triangles

Area of rectangle =

Area of triangle =

Exercise 2.k

A train's motion can be represented by the graph below. Calculate the distance the train travels in a. 15s, b 60s.

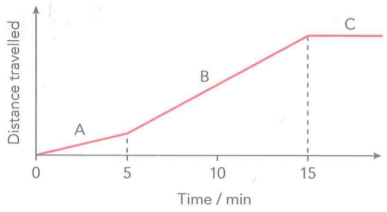
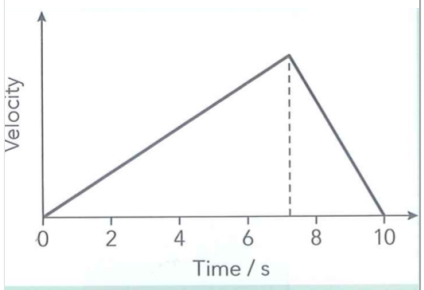


Exercise 2.l

Draw a speed-time graph to show a car that accelerates uniformly from 6m/s for 5s then travels at a steady speed go 12m/s for 5s.

On your graph, shade the area that shows the distance travelled by the car in 10s.

Calculate the distance travelled in this time.

	distance-time graph	speed-time graph
example		
distance		
speed		
acceletation		