Many authors prefer to use the term ‘directed line segment’ rather than ‘arrow’ when describing vectors.

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The advantage of using $|\boldsymbol{r}|$ rather than r to represent the magnitude of a vector is that it makes it less likely that you will forget that it cannot be negative.

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The terms dependent variable and independent variable are defined in the Glossary.

In graphs of one-dimensional motion this convention leads to x on the vertical axis, and you might find this surprising at first.

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When plotting points and drawing graphs it is generally best to use *squared graph paper*, to choose scales with *decimal subdivisions* and to select the scales in such a way that the graph is as large as possible, since this improves accuracy.

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In the remainder of this module we will adopt a convention for dealing with velocity in one dimension that is similar to the one we have used for position and displacement. We will refer to the x-component of the velocity v_x as 'the velocity', even though it is really only one component of a vector quantity.

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In general, angular brackets $\langle \ldots \rangle$ are used to indicate ‘an average value of’, as in Equation 5.

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The idea of a *limit* is discussed more fully in the maths strand of *FLAP*. See the *Glossary* for further details and references.

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The *tangent* to a curve at a point is the straight line passing through that point which (usually) just meets the curve at the point of contact without crossing it.

The techniques of *calculus* are fully discussed in the maths strand of *FLAP*.

The term *velocity* is generally used as shorthand for *instantaneous velocity* and it will be used as such in the remainder of this module, unless it is qualified as *average velocity*.

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Note that if $s_x = x_2 - x_1$ then in general

$$\frac{ds_x}{dt} = \frac{dx_2}{dt} - \frac{dx_1}{dt}$$

For the case where displacements from a fixed position are involved (x_1 = constant) then

$$\frac{ds_x}{dt} = \frac{dx_2}{dt}$$

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It is a common mistake to describe deceleration as negative acceleration. This is sensible when v_x is positive but if v_x is negative, a negative acceleration will cause $|v_x|$ to *increase*; this is not what we normally mean by deceleration!

In the remainder of this module we will adopt a convention for dealing with acceleration in one dimension that is similar to the one we have been using for position, displacement and velocity. We will refer to the x-component of the acceleration, a_x, as 'the acceleration', even though it is really only one component of a vector quantity.

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The acceleration due to gravity, like all accelerations, is a vector quantity, directed vertically downwards in this case. Since the direction is implied we will deal here only with the *magnitude* of this acceleration g.

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Note that v_{x2} is the velocity at time t_2 and v_{x1} is the velocity at time t_1.

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You may find it helpful to draw a grid on Figure 17.

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The term *acceleration* is often used as shorthand for *instantaneous acceleration* and it will be used as such in the remainder of this module.

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By ‘area under the graph’ we mean the area between the graph itself and the horizontal axis. Usually we are only concerned with the part of this area that lies between vertical lines drawn at given times such as t_1 and t_2.

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Note that this simple method of calculating average speeds only works if the acceleration is uniform.

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It is worth noting that in the case of uniform acceleration, Equation 12

$$s_x = \frac{u_x + v_x}{2} t \qquad \text{(Eqn 12)}$$

is the algebraic expression of the general principle that the change in displacement is equal to the area under the velocity–time graph.

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✧

In physical terms, $|\boldsymbol{s}|$ is the *distance* between the two points and it makes no sense to speak of a negative distance. In mathematical terms the quantity $|\boldsymbol{s}|$ cannot be negative. ❑

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✧

The pedestrian is 50 m to the *left* of the car and position coordinates are increasing to the *right*, so the displacement from the car to the pedestrian is –50 m. Alternatively, using Equation 2

$$s_x = x_2 - x_1 \qquad \text{(Eqn 2)}$$

$s_x = x_2 - x_1 = -20\text{ m} - (+30\text{ m}) = -50\text{ m}$

The distance from the car to the pedestrian is $|s_x| = 50\text{ m}$. ❑

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✧

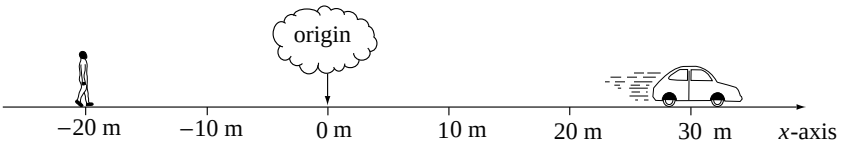

Figure 10 The new coordinate system. (The new origin is displaced (+)20 m from the old origin, i.e. 20 m to the right.)

It must be 20 m to the right of the old origin, as in Figure 10. The journey now starts at a position –20 m from the origin. ❑

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✧

As expected, the answer is once again $3.1\ \mathrm{m\,s^{-1}}$. ❑

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✧

The fact that the velocity is positive shows that the car is moving in the direction of increasing x values. If it had been moving in the opposite direction the velocity would have been $-3.1\ \mathrm{m\,s^{-1}}$ but the speed would still have been $3.1\ \mathrm{m\,s^{-1}}$. Thus the speed carries no information about the direction of motion even if it happens to be numerically equal to the velocity. ❑

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✧

If the cars are moving with the same speed but have different velocities, they must be moving in opposite directions along the line. Therefore their velocities are opposite so $v_{x1} = -v_{x2}$. ❑

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✧

If the position–time graph is linear, in other words, if the graph is a straight line, then the object must be travelling at a constant velocity, because equal changes in position coordinate occur in equal intervals of time. ❑

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✧

Since acceleration is the rate of change of velocity, and since velocity is measured in m s^{-1}, the appropriate units for a and a_x are m s^{-2}. ❑

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✧

The gradient of the tangent (and hence the acceleration) at $t = 3.5$ s is $3.9\ \mathrm{m\,s^{-2}}$. The average acceleration, using Equation 7 with the data taken from the graph, 0.25 s either side of 3.75 s, is

$(30 - 28)\ \mathrm{m\,s^{-1}}/0.50\ \mathrm{s} = 3.9\ \mathrm{m\,s^{-2}}$. ❑

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✧

The average speed is half the sum of the initial and final speeds ☞, i.e. [(0 + 60)/2] mph or 30 mph. You met this idea in Question T10. ❑

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✧

The distance travelled is found by multiplying this average speed of 30 mph by the time taken, which is 8 s (or 8/3600 h). The car thus travels $(30 \times 8/3600)$ miles, i.e. 0.067 miles. ❑

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✧

If the initial velocity is u_x and final velocity is v_x then the average velocity is $(u_x + v_x)/2$. ❑

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