SPH3U UNIVERSITY PHYSICS

KINEMATICS

- Distance, Position, & Displacement (P.8-11)

Physical Quantities

Many things that we do can be measured and described: how much time we spend in school, the mass of the candy we buy, and the force with which we throw a baseball. Time, mass, and force are examples of physical quantities. Physical quantities can be classified as either scalar quantities or vector quantities.

- *A **scalar** quantity has magnitude (size) only. For example, a distance of 2.5 m, a speed of 23 m/s, a time interval of 15 s.*

- *A **vector** quantity has magnitude (size) and also a direction (which are often expressed in square brackets after the measurement). For example, a displacement of 2.5 m[N], a velocity of 23 m/s[E], a force of 15 N[S].*

Physical Quantities

SCALAR

- quantity that has only magnitude (size)

VECTOR

- quantity that has magnitude (size) and direction

NOTE!

An arrow above a variable indicates it is a vector quantity.

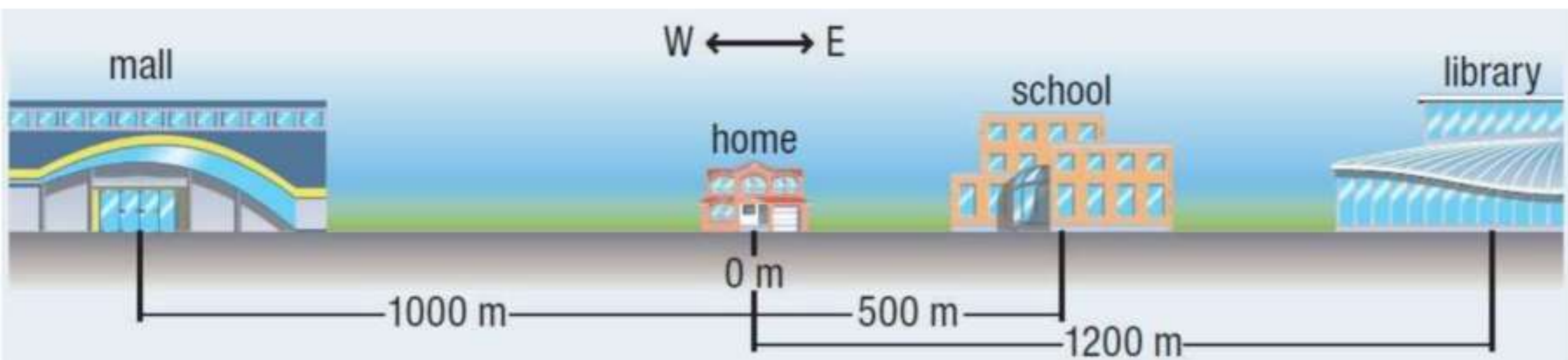
Physical Quantities

PRACTICE

1. Indicate whether each of the following is a vector or scalar quantity.
   (a) 50 km/h S
   (b) 6 km/h[N] V
   (c) 2000 kg/m^3 S
   (d) 6 centuries S
   (e) 800 kg S
   (f) 1.0 kg/week S
   (g) 20 m/s[S] V
   (h) 400 N[down] V

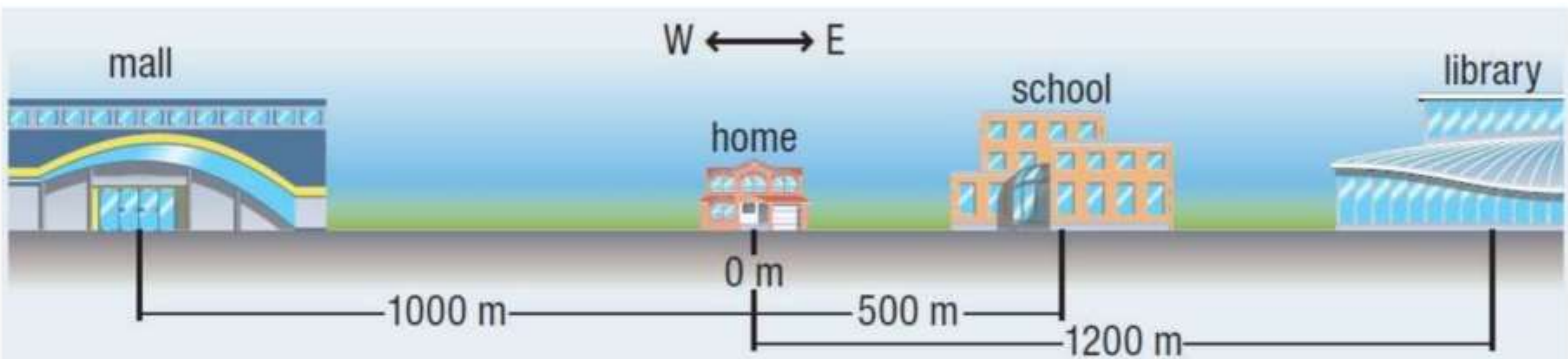
Distance

Distance *is the total length of the path travelled by an object in motion. Distance is a scalar quantity represented by the symbol* ***d****. For example, if you walk directly from home to the school in a straight line, you will travel a distance of 500 m. If you walk from the school to the library and then return home, you will travel 1900 m (700 m + 1200 m).*



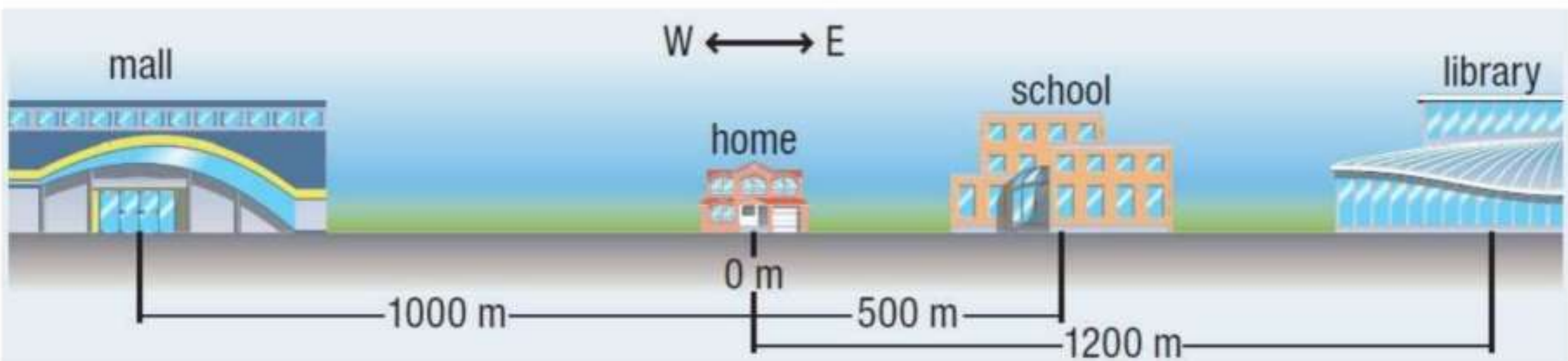
Position

Position *is the distance and direction of an object from a particular reference point. Position is a vector quantity represented by the symbol* $\vec{\boldsymbol{d}}$. *For example, if home is your reference point, the position of the school is 500 m[E]. Note that the magnitude of the position is the same as the straight-line distance (500 m) from home to school, but the position also includes the direction (due east [E]).*



Displacement

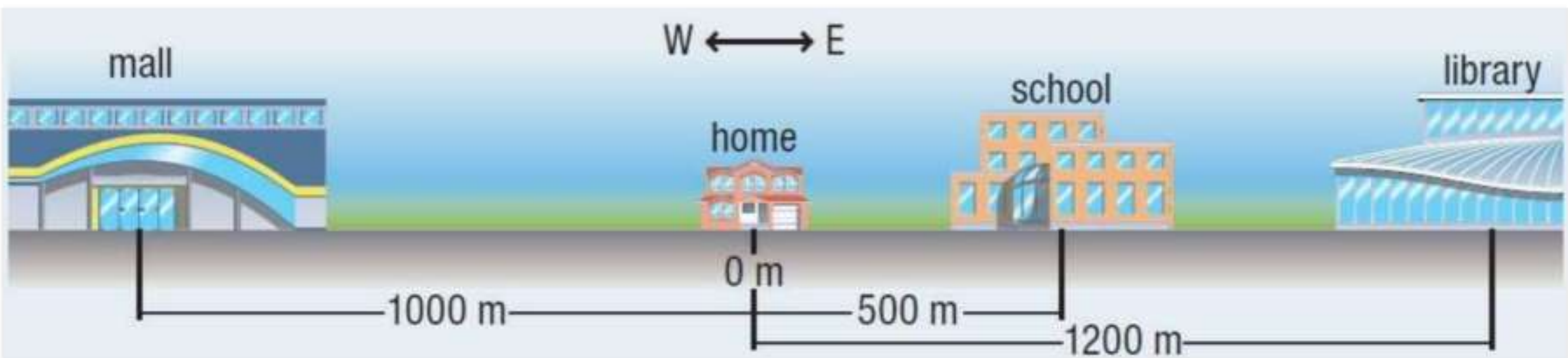
Once the position of an object has been described, you can describe what happens to the object when it moves from that position. This is ***displacement*** *– the change in an object's position. Displacement is represented by the symbol* $\boldsymbol{\Delta\vec{d}}$ *(Δ means "change in").*



Displacement

As with any change, displacement can be calculated by subtracting the initial position vector from the final position vector:

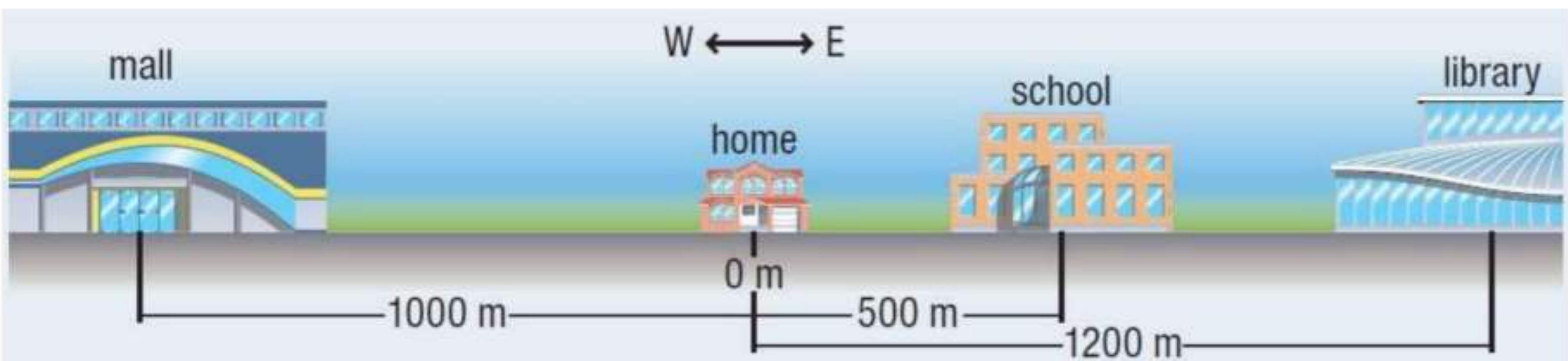
$$\Delta\vec{d} = \vec{d}_{final} - \vec{d}_{initial}$$



Displacement

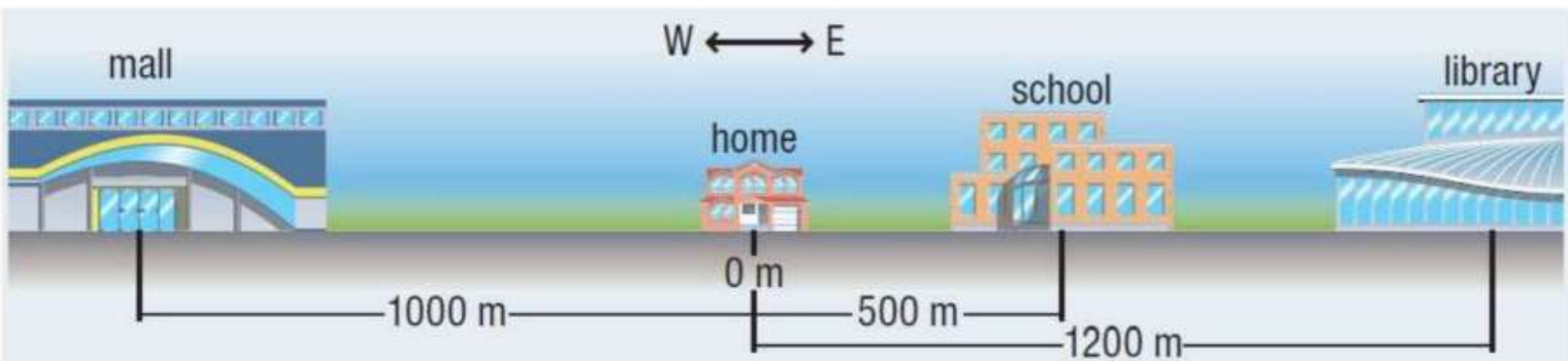
And when an object changes its position more than once (i.e., it experiences two or more displacements), the total displacement of the object can be calculated by adding the displacements using the following:

$$\Delta\vec{d}_T = \Delta\vec{d}_1 + \Delta\vec{d}_2 + \ldots$$



Displacement

For example, if you walk directly from home to school your displacement is 500 m[E] (500 m[E] – 0). If you then walk from the school to the library and then return home, your total displacement will be 0 m (500 m[E] + 700 m[E] + 1200 m[W]). Recall that displacement is the change in position.



Distance, Position, & Displacement

DISTANCE (d)

- total length of the path travelled by an object in motion

POSITION ($\vec{d}$)

- distance and direction of an object from a particular reference point

DISPLACEMENT ($\Delta\vec{d}$)

- change in the position of an object

NOTE!

The SI unit for distance, position, and displacement is the metre (m).

Distance, Position, & Displacement

DISPLACEMENT

$$\boxed{\Delta\vec{d} = \vec{d}_f - \vec{d}_i}$$

where $\Delta\vec{d}$ is the displacement
$\vec{d}_f$ is the final position
$\vec{d}_i$ is the initial position

TOTAL DISPLACEMENT

$$\boxed{\Delta\vec{d}_T = \Delta\vec{d}_1 + \Delta\vec{d}_2 + \ldots}$$

where $\Delta\vec{d}_T$ is total displacement
$\Delta\vec{d}_1$ is displacement #1
$\Delta\vec{d}_2$ is displacement #2

NOTE!

① *A common term for total displacement is **resultant displacement**.*
② *For convenience, the arrows in the formulas above are often dropped.*

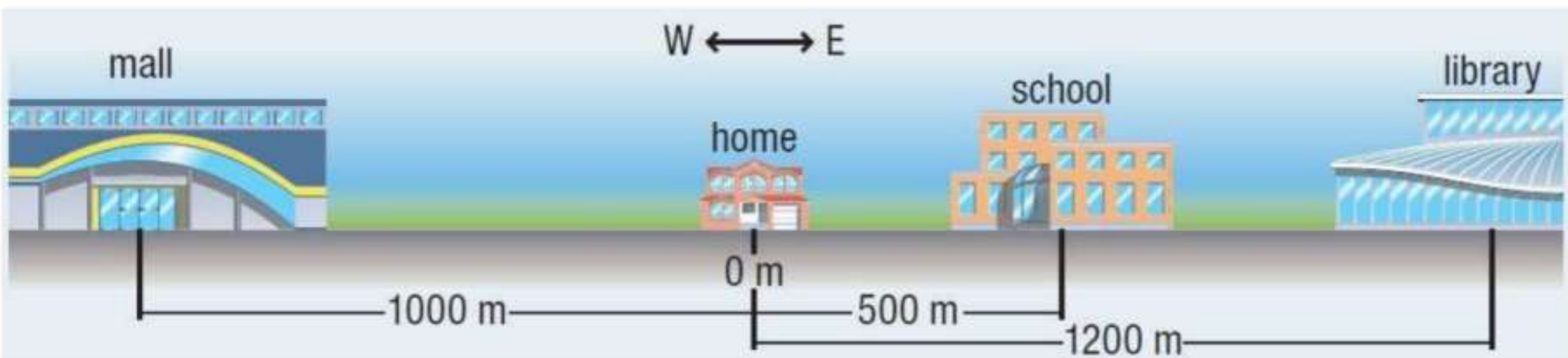
Distance, Position, & Displacement

PRACTICE

2. What is your (i) distance and (ii) displacement if you:

   (a) walk from home to the library and then back home?

(a) $d = 2400$ m; $\Delta d = 0$ m

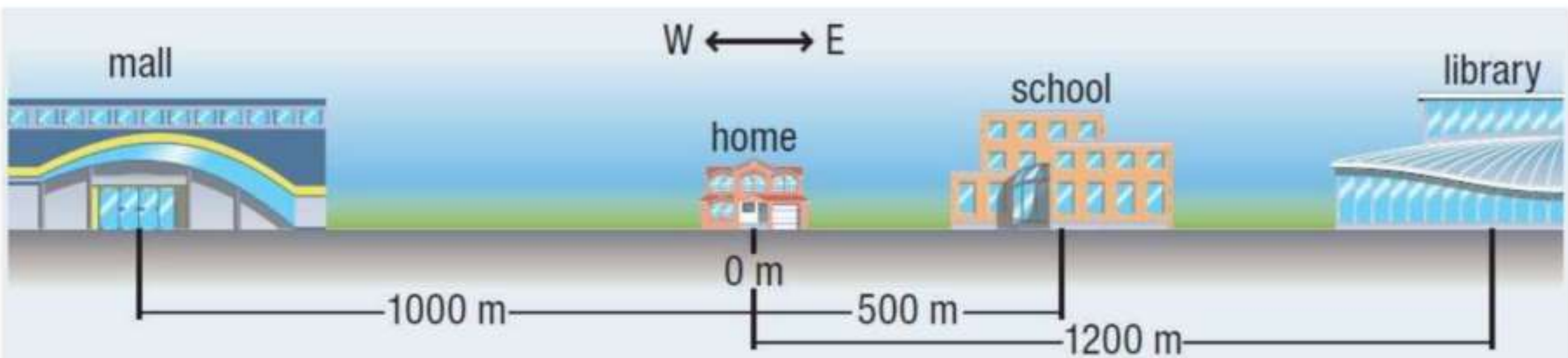


Distance, Position, & Displacement

PRACTICE

2. What is your (i) distance and (ii) displacement if you:
   (b) walk from the school to home and then to the library?

(b) $d = 1700$ m; $\Delta d = 700$ m[E]

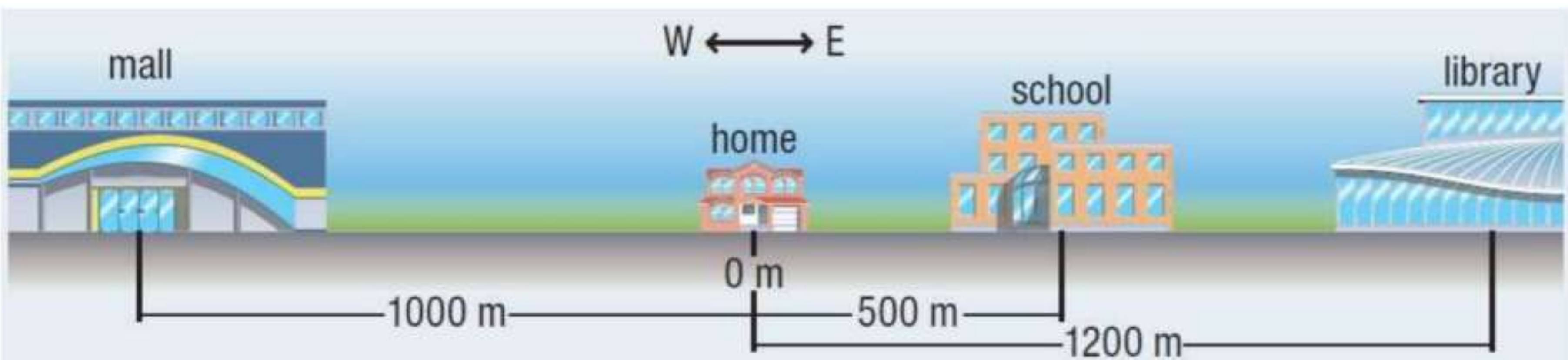


Distance, Position, & Displacement

PRACTICE

2. What is your (i) distance and (ii) displacement if you:
   (c) walk from home to the school and then to the mall?

(c) $d = 2000$ m; $\Delta d = 1000$ m[W]



Distance, Position, & Displacement

PRACTICE

3. A dog, practising for her agility competition, leaves her trainer and runs 80 m due west to pick up a ball. She then carries the ball 27 m due east and drops it into a bucket. What is the dog's total displacement?

$\Delta d = 53\ m[W]$

Distance, Position, & Displacement

PRACTICE

4. A car changes its position from a position 52 km[W] of home to a position 139 km[E] of home. What is the car's displacement?

$\Delta d = 191$ m[E]