Introduction to Motion

Scalars and Vectors

All physical quantities can be divided into two groups – scalers and vectors

When determining if a quantity is a vector or a scaler you need to ask 1 question, does direction matter?

- **Vector - quantity with both magnitude (size or numerical value) and direction**
- **Scalar - quantity with magnitude (size or numerical**
- **value) only**

Do you know the difference?

Quantity	Category
5 m	Scalar
30 m/sec, East	Vector
5 mi., North	Vector
456 cm	Scalar
5.04 m South East	Vector
615km	Scalar

Describing Motion

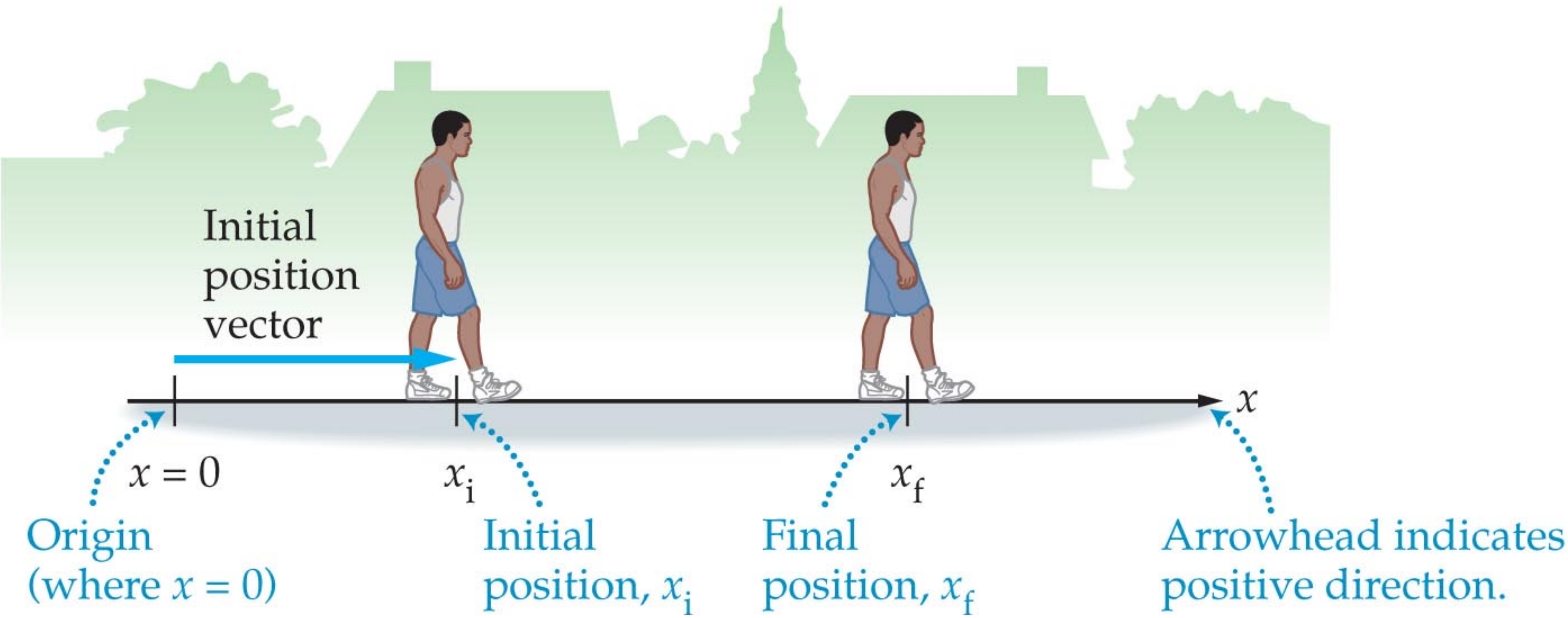
- A frame of reference is referred to as a coordinate system.
- A coordinate system in one dimension is represented by an *x* axis with the origin located at $x = 0$.
- Once an origin and a positive direction are chosen, they must be used consistently.

Describing Motion

- The letter *x* is used to label position.
- An arrow drawn from the origin of a coordinate system to an object is referred to as the object's position vector.
- Whenever an object is in motion, its position is changing.

Describing Motion

- Initial and final positions are indicated with x_i and x_f, respectively.



Describing Motion

- **Distance (d) is the total length of the path taken on a trip.**
  - No direction is associated with distance. It is a scalar quantity.
  - The SI unit of distance is the meter (m).
  - When walking, distance is measured with a pedometer.
  - In a car, the distance is measured using an odometer.

Describing Motion

- **Displacement (Δx) is defined as an object's change in position**.
  - Displacement is a vector having both magnitude and direction.
  - The SI unit of displacement is the meter (m).
- Examples of directions:
  - + and –
  - N, S, E, W
  - Angles

How to remember

D I. S. T. A. N. C. E

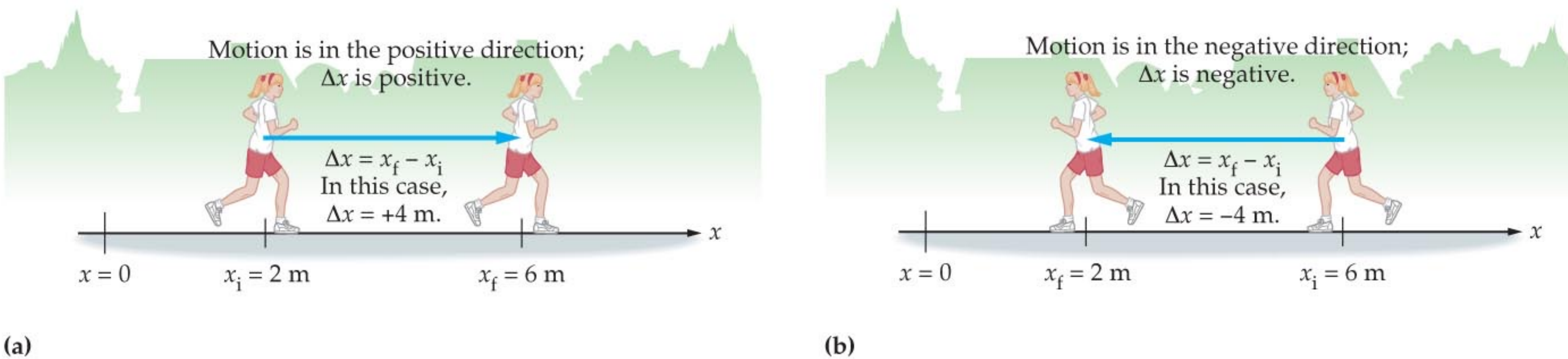
Traveled Total

D. I. S. P. L. A. C. E. M. E. N. T

Position Change

Describing Motion

- Displacement is represented by the symbol Δ*x*.
- Δ*x* is shorthand for $x_f - x_i$. It does not mean Δ times *x*.
- Δ*x* is <u>positive</u> when the change in position is in the positive direction and <u>negative</u> when the change in position is in the negative direction.



Describing Motion

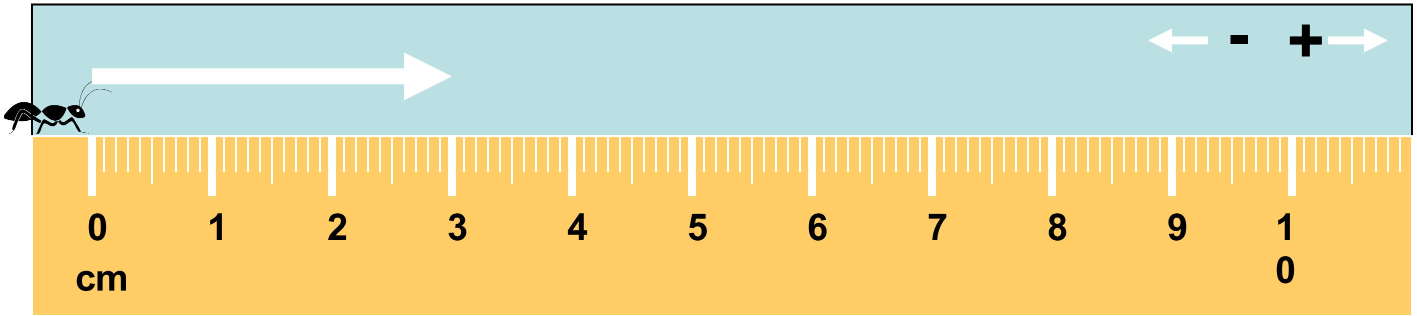
- Distance is the total length traveled; displacement is the net change in position.
- An object's displacement is zero when it returns to its starting point, even though it may have traveled a considerable distance.

Video Example

- https://www.youtube.com/watch?v=9z-EIcdJ9VY

Distance and Displacement

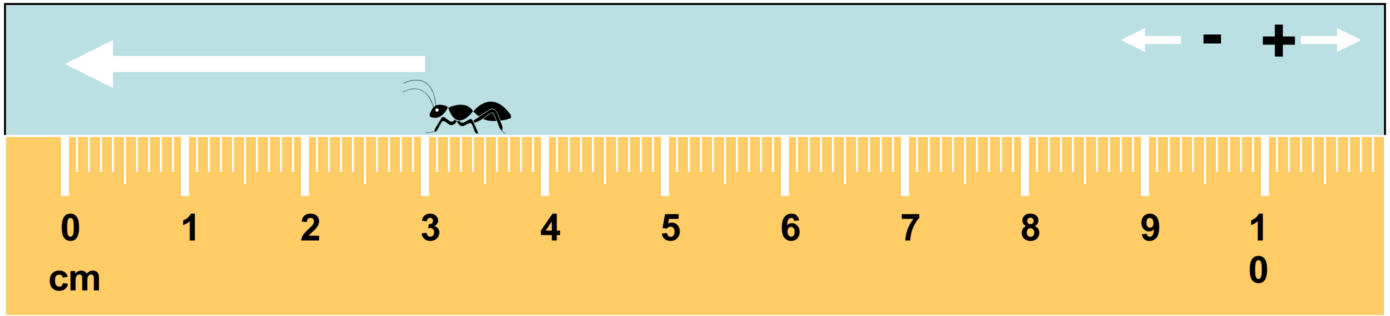
- Let’s visit our ant, and we we’ll find his distance and displacement.



- Distance: 3 cm
- Displacement: +3 cm
  - The positive gives the ant a direction!

Distance and Displacement

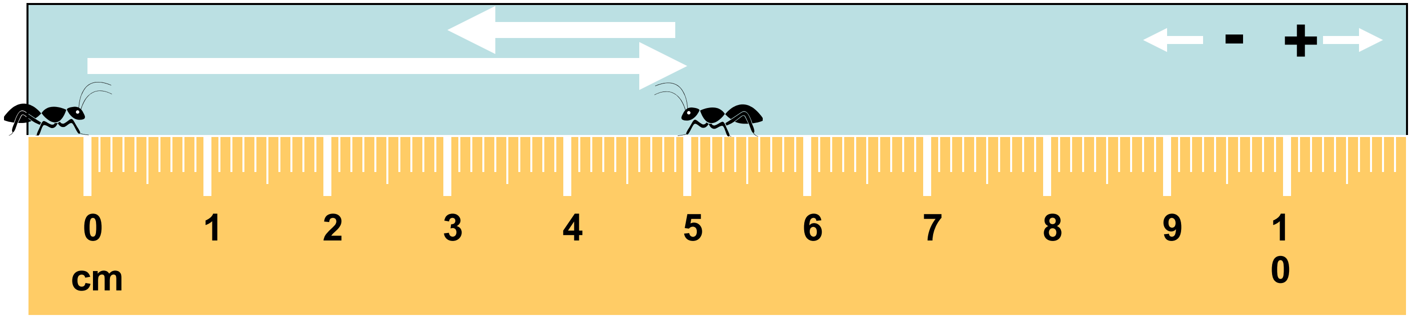
- Find the ant's distance and displacement again.



- Distance: 3 cm
- Displacement: -3 cm

Distance and Displacement

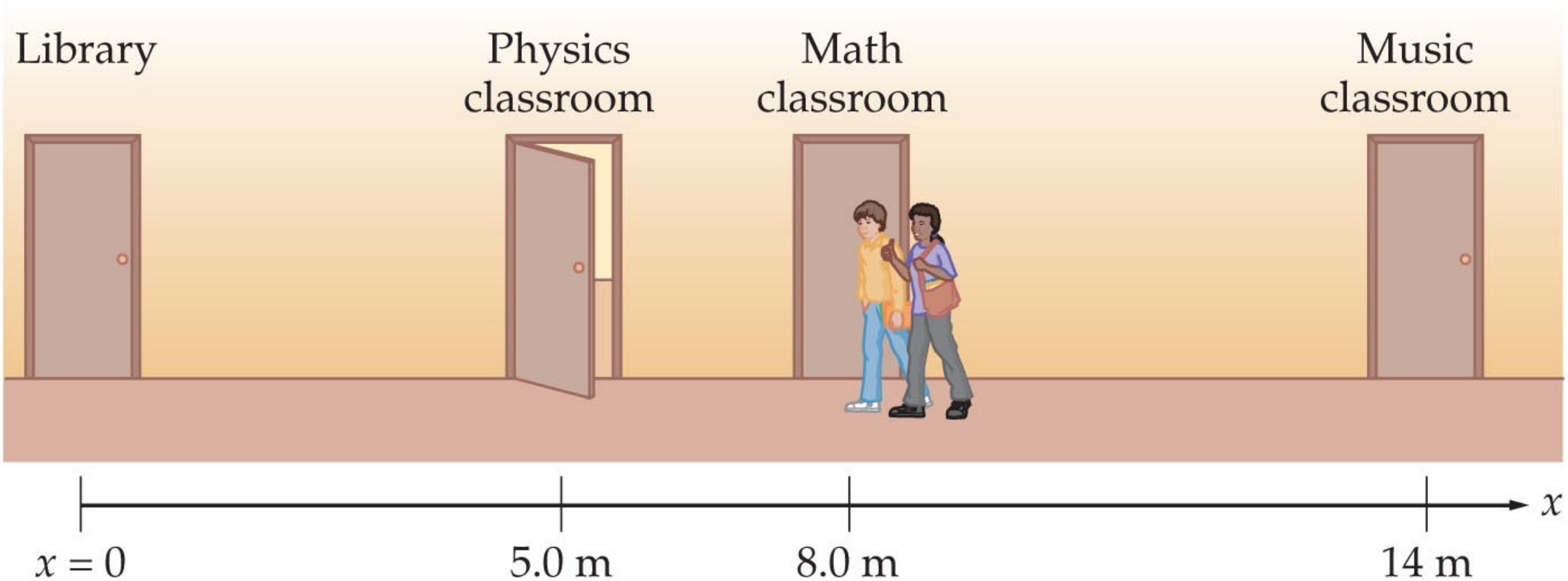
- Find the distance and displacement of the ant.



- Distance: 7 cm
- Displacement: +3 cm

Describing Motion

- Example: The total length traveled in going from the math classroom to the library and then to the physics room is 13.0 m, whereas the displacement is −3.0 m.

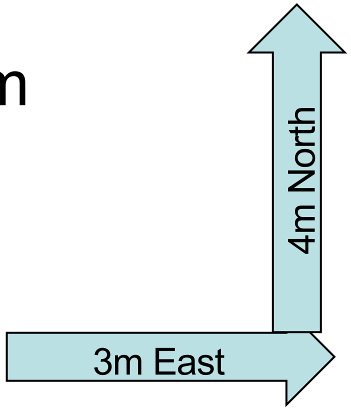


Displacement and Distance in 2 Directions

- You walk 3m east.
- Than turn and go 4m North.
- What is the distance of the walk?

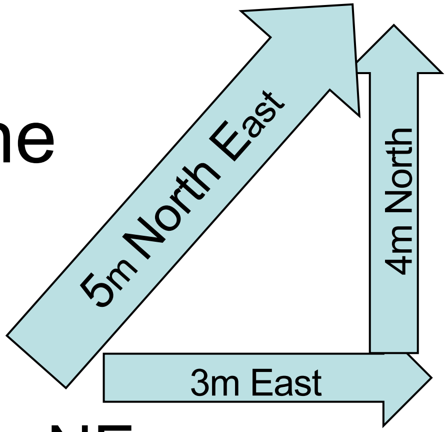
- Distance -

3m + 4m = 7m



Displacement and Distance in 2 Directions

- You walk 3m east.
- Than turn and go 4m North.
- What is the displacement of the walk?



Pythagorean theory

$A^2 + B^2 = C^2$

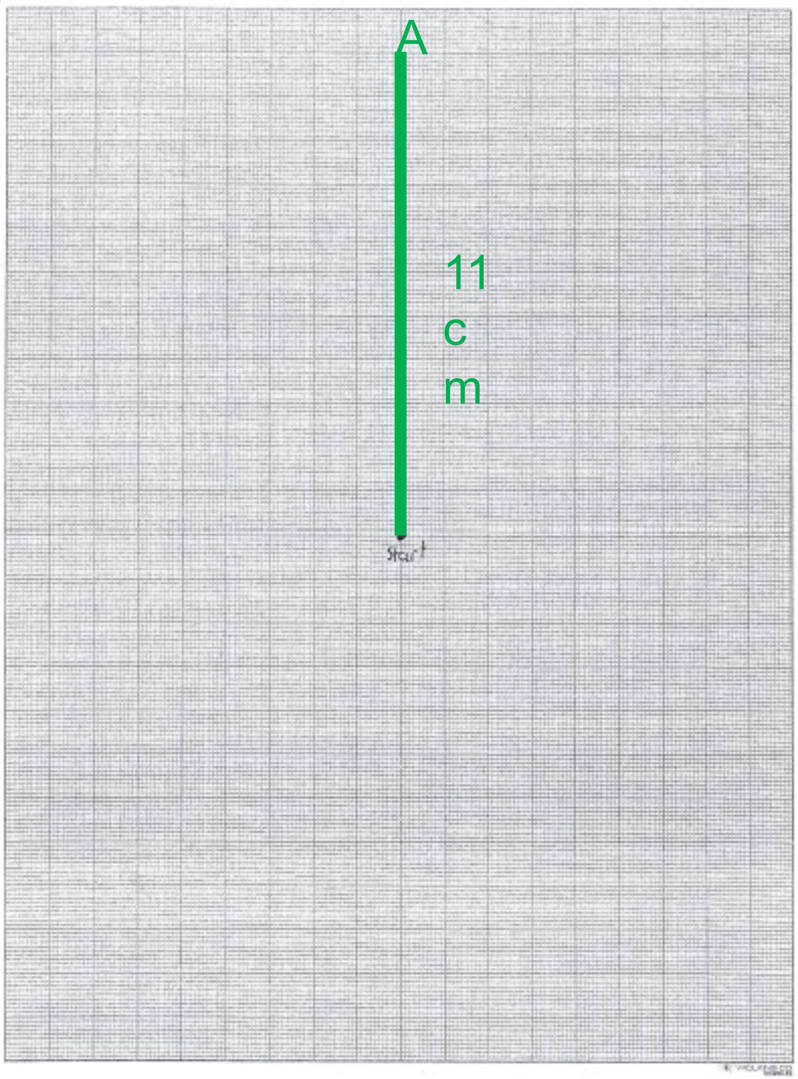
$3^2 + 4^2 = C^2$

$9 + 16 = C^2$

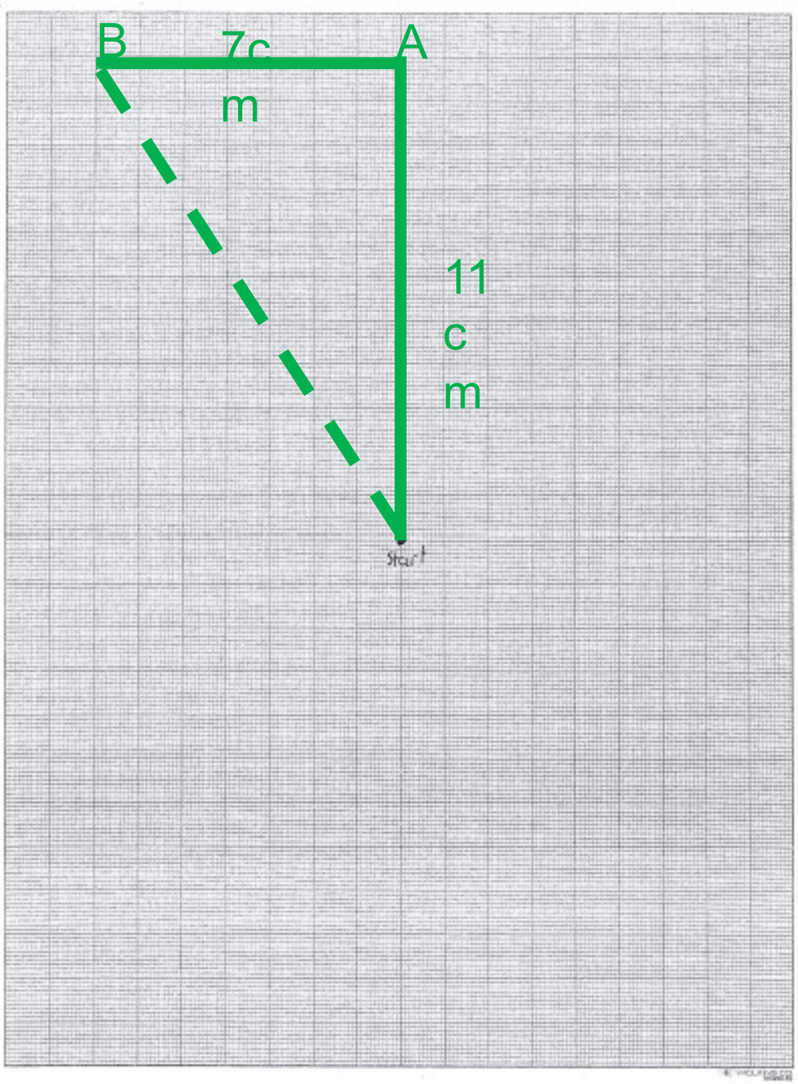
$25 = C^2$

$\sqrt{25} = C$

- Displacement - 5m NE



- Distance start to A – 11cm
- Total Distance – 11cm
- Displacement - 11cm N



- Distance A to B – 7cm

- Total Distance –
  11cm + 7cm = 18cm

- Displacement - $A^2 + B^2 = C^2$
- $7^2 + 11^2 = C^2$
- $49 + 121 = C^2$
- $170 = C^2$
- $\sqrt{170} = C$
- C = 13.04 NW

Position-Time Graphs

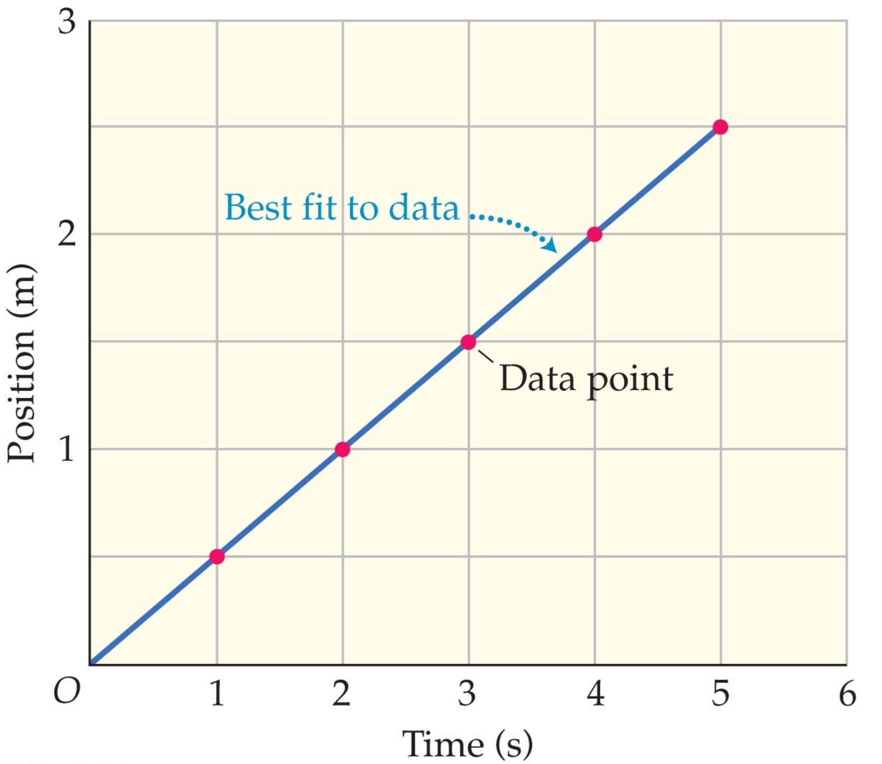
- A position-time graph is an alternative way of representing data in a table.
- On a position-time graph, position data are plotted on the *y* axis; time data are plotted on the *x* axis.

Position-Time Graphs

- Example: Plotting the position and time contained in a table results in a position-time graph.

Table 2.1 Position and Time Data

Time (s)	Position (m)
0.0	0.0
1.0	0.5
2.0	1.0
3.0	1.5
4.0	2.0
5.0	2.5

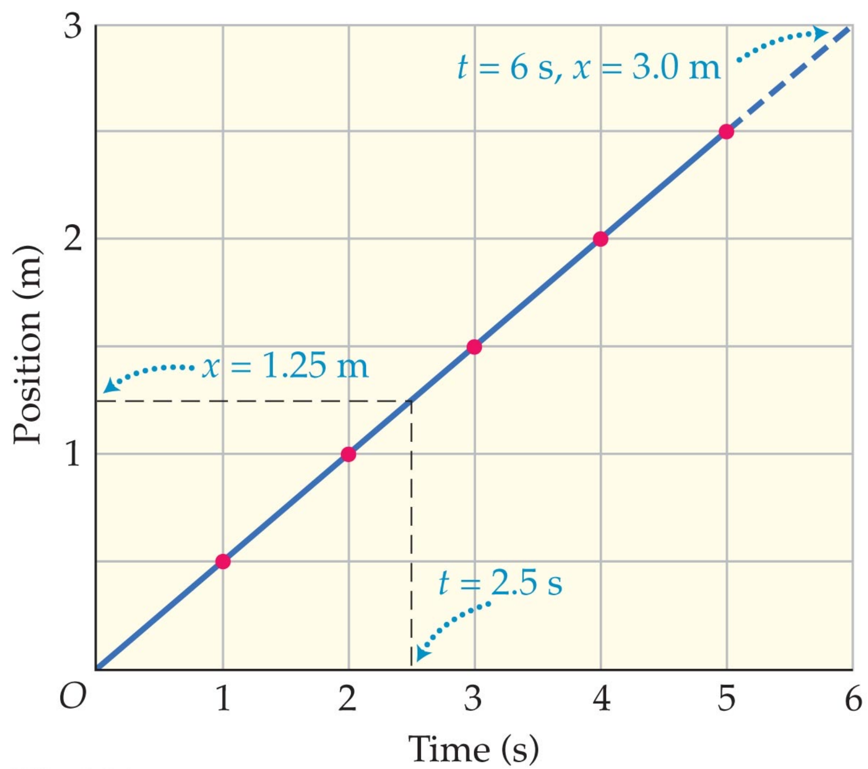


Position-Time Graphs

- A best-fit line drawn through data points can be used to learn additional information about an object's motion.

Position-Time Graphs

- To find position at a time not in original data,
  - trace vertically from a given point on time axis to the straight line, then
  - trace sideways until you reach the position axis.



Position-Time Graphs

- The slope of a straight line is equal to its rise over its run.
- Any two points may be used to calculate the slope of a straight line.
- On a position-time graph the rise corresponds to the an object's position and the run to the elapsed time.