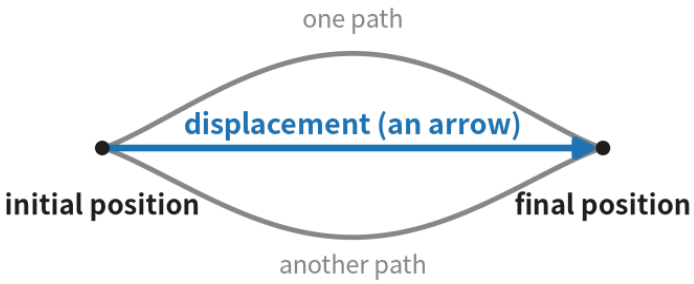
Distance vs Displacement

Physics with Tiaotiao 跳跳 · Kinematics · High School Physics

Study sheet for the video "Distance vs Displacement": key ideas and practice questions (answers are in a separate answer key)

Key ideas

1. Definitions.
Displacement describes the *change in position*. It is a vector: an arrow from the initial position to the final position. Its length is the straight-line distance between the two positions. It does not depend on the path.
Distance is the length of the path actually travelled. It is a scalar (just a number), and it depends on the motion.



Example: run one lap of a 400 m track and come back to the start. Displacement $x = 0$. Distance $s = 400$ m.

2. Writing 1D displacement: a sign plus a number. The sign gives the direction; the number gives the magnitude.

Axis: B at −2, O at 0, A at 3 (right is positive)	Value
O to A: to the right, same as positive	$x_{OA} = +3$ m (the + may be left out)
O to B: to the left, opposite to positive	$x_{OB} = -2$ m
A to B (from 3 to −2): to the left, 5 units	$x_{AB} = -5$ m

3. Displacement from coordinates: displacement = final coordinate − initial coordinate. Never subtract the other way round.
0 to 1: +1 m = 1 − 0 · −2 to 2: +4 m = 2 − (−2) · 3 to −2: −5 m = −2 − 3
Careful: the + or − in a coordinate such as −1 or 3 only tells which side of the origin the point is on. It is not a math sign. Treating it as a math sign in the subtraction just happens to give the displacement.

4. Comparing distance and displacement. You **cannot** compare distance with displacement: one is a number, the other is an arrow. You can compare distance with the **magnitude** of the displacement:
distance ⩾ magnitude of displacement
Equality holds **only in one-way straight-line motion**. If the object turns back, even on a straight line, distance > magnitude of displacement.

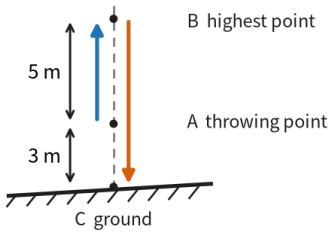
Practice

Try these first. The answers are in a separate answer key.

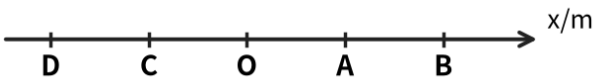
1. As shown, a ball is thrown straight up from point A, 3 m above the ground. It rises 5 m, then falls back and finally reaches the ground at point C. What is the magnitude of the ball's displacement from A to C? ( )

A. 3 m B. 5 m C. 8 m D. 16 m

Answer: ____ Why?



2. A particle moves back and forth along a straight line, as shown. OA = AB = OC = CD = 1 m, O is the origin of the x-axis, and the direction shown is positive. The particle starts at A, moves in the positive x direction to B, then returns in the negative x direction. Which statements are correct? ( ) (Select all that apply.)



A. From A→B→C, the displacement is 2 m and the distance is 4 m

B. From B→D, the displacement is −4 m and the distance is 4 m

C. When the particle reaches D, its position can be written as D's coordinate, −2 m

D. When the particle reaches D, its displacement relative to A is −3 m

Answer: ____ ____ Working:

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3. A person runs 1¾ laps around a horizontal circle of radius R. His ( )

A. Distance and magnitude of displacement are both 3.5πR

B. Distance is 3.5πR; magnitude of displacement is $\sqrt{2}R$

C. Distance and magnitude of displacement are both R

D. Distance is 0.5πR; magnitude of displacement is $\sqrt{2}R$

Answer: ____ Working:

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4. Decide whether each statement is true (T) or false (F).

____ (1) In straight-line motion, the magnitude of the displacement equals the distance.

____ (2) In one-way straight-line motion, an object's distance equals its displacement.

____ (3) If an object's displacement is zero, its distance is not necessarily zero.

____ (4) The greater a moving object's distance, the greater its displacement.

____ (5) The "25 km" on an expressway sign means the displacement from here to the next exit is 25 km.

One-line summary

Displacement is an arrow (final − initial); distance is a number. Compare distance only with the magnitude of displacement: it is never smaller, and equal only for one-way straight-line motion.

Key terms

Term	Meaning	Chinese
displacement	a vector arrow from the initial to the final position	位移 wèiyí
distance	the length of the path actually travelled (a scalar)	路程 lùchéng
initial / final position	where the motion starts / ends	初位置 / 末位置 chūwèizhì / mòwèizhì
magnitude	the size of a vector, without direction	大小 dàxiǎo
coordinate	the number that gives a position on an axis	坐标 zuòbiāo
one-way straight-line motion	straight-line motion with no turning back	单向直线运动 dānxiàng zhíxiàn yùndòng