Distance vs Displacement

Physics with Tiaotiao 跳跳 · Kinematics · High School Physics

Study sheet for the video "Distance vs Displacement": key ideas, practice questions, answers

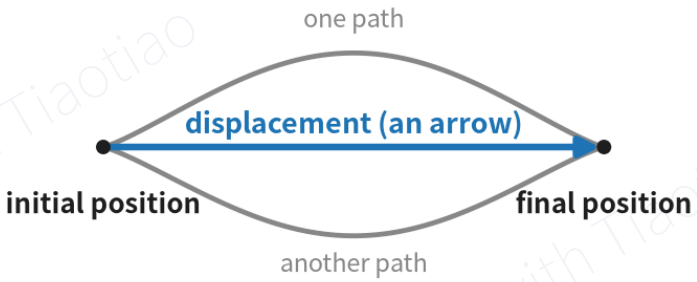
Matches: NCERT Class 11 Ch 2 · FSc Part 1 Ch 3 · AS & A Level 9702 · WAEC/JAMB · HSC · AP Physics 1 Unit 1 · College Physics

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.

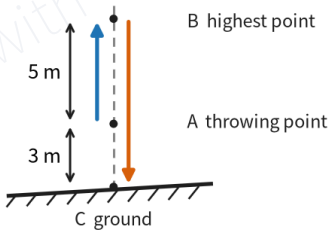
Practice

Try these before checking the answers on the next page.

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:

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:

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.

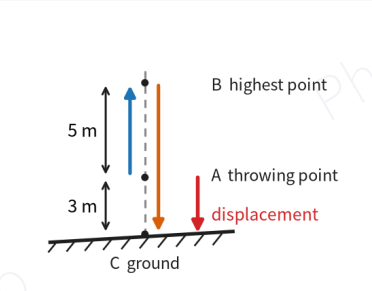
_____ (4) The greater a moving object's distance, the greater its displacement.

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

Answers and explanations

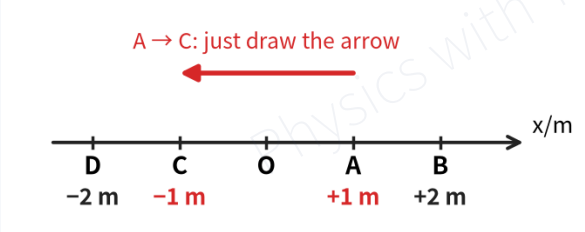
Tap a blue time to jump to the part of the video that explains the question.

1. A. Displacement only looks at the change in position from start to end, not at the motion in between. A and C are 3 m apart on a vertical line, so the magnitude is 3 m, pointing down from A to C.
For comparison, the distance is 5 + 5 + 3 = 13 m: the whole path added up.



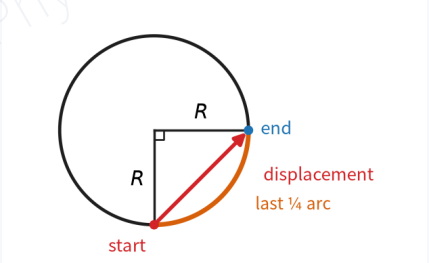
▶ **Watch 13:14, Example 1**

2. B, C, D are correct; **A** is wrong.
Coordinates: $x_A = 1$ m, $x_B = 2$ m, $x_C = -1$ m, $x_D = -2$ m. Use final − initial.



A From A to C the displacement is −1 − 1 = −2 m, not 2 m: the sign is missing. (The distance 1 + 3 = 4 m is right, but the statement is still wrong.)
B $x_D - x_B = -2 - 2 = -4$ m. B to D is all to the left, so the distance is 4 m.
C On a 1D axis one number gives a position. At D the coordinate is −2 m: the sign says which side of O, the number says how far from O.
D $x_D - x_A = -2 - 1 = -3$ m.
Tip: never drop the sign of a displacement. "Final minus initial" will not lose it.
▶ **Watch 14:05, Example 2**

3. B. Distance is the length of the path: 1¾ = 7/4 laps, each lap is 2πR, so $s = 7/4 \times 2\pi R = 3.5\pi R$.



Displacement magnitude is the straight line from start to end. After 1 full lap and ¾ of a lap, exactly a quarter arc is left, so start, centre and end make a right angle. The two radii R are the short sides, and the displacement is the hypotenuse: $\sqrt{(R^2 + R^2)} = \sqrt{2}\,R$.
▶ **Watch 16:18, Example 3**

4. **(1) F** **(2) F** **(3) T** **(4) F** **(5) F**
(1) "One-way" is missing. With turn-backs, distance is greater than the magnitude of displacement.
(2) Distance is a number and displacement is an arrow, so they cannot be equal. It should say "distance equals the *magnitude* of the displacement". Exam tip: compare distance only with the magnitude.
(3) True. Run one lap and come back: displacement is 0, distance is not.
(4) Run one lap, or a bigger lap: distance grows, displacement is still 0.
(5) The 25 km is the length of the road you drive (it may have curves), not the straight line to the exit. It is a distance.
▶ Watch 17:39, Example 4

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