Vectors vs Scalars

Physics with Tiaotiao 跳跳 · Kinematics · High School Physics

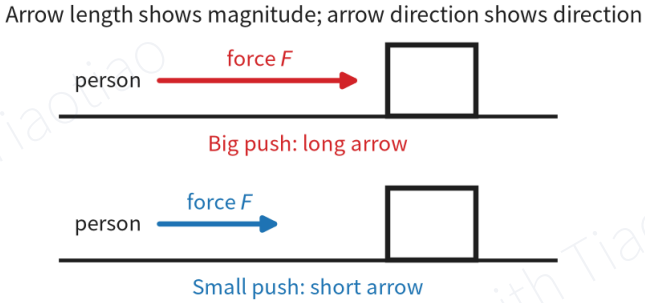
Study sheet for the video "Scalars vs Vectors Explained": key ideas, practice questions, answers

Matches: NCERT Class 11 Ch 3 Motion in a Plane (scalars and vectors) · FSc Part 1 Ch 2 Vectors and Equilibrium · AS & A Level 9702 · WAEC/JAMB · HSC · College Physics · AP Physics 1 Unit 1

Key ideas

Vector: a physical quantity with both **magnitude** and **direction**. It is drawn as an **arrow**: the length shows the magnitude, the arrow's direction shows the direction. Examples: velocity, force.

Scalar: a physical quantity with **magnitude only**. It is written as a **number**. Examples: mass, volume, temperature.



Simple notation for 1D vectors (vector algebraization): a vector with only two directions is a **1D vector**. Pick one direction as **positive** (right, say). Then a vector is just **a number with a sign**. Example: the displacement from O to A points right and is 3 m long, so $\mathbf{x_{OA} = +3\ m}$. Forces and velocities are written the same way: +5 N, −2 N, +5 m/s, −3 m/s.

Only 1D vectors can be written like this. A 2D vector has endless directions, and + and − are not enough.

Comparing vectors: ignore the sign, look only at the numbers. 10 N is bigger than 3 N.

Real and fake directions: a **real direction** is a direction in space: you can say east, west, south or north. A **fake direction** is not a direction in space: you can't say east, west, south or north (e.g. "aiming for a score of 90"). Only vectors have real directions. Some scalars have a direction, but it is always fake.

Quick test: say "it points 37.5° south of east". Sounds odd? Fake direction, so a scalar (current). Sounds fine? Real direction, so a vector (velocity).

Three uses of the + and − signs

Use	Example
1. Positive and negative numbers (order of size)	−3 is smaller than +2
2. The direction of a 1D vector: + same as the positive direction, − opposite	F_1 = +3 N, F_2 = −10 N
3. The two values of a property	A battery's poles: positive pole, negative pole

+ and − are just an ordinary pair of symbols. They need not show size, and not only vectors have them.

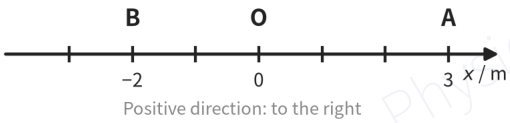
Practice

1. Write V (vector) or S (scalar) for each quantity.

_____ (1) velocity _____ (2) force _____ (3) mass

_____ (4) volume _____ (5) temperature _____ (6) displacement

2. On the axis below, O is the origin, A is at 3 m and B is at −2 m. Take the positive direction to the right.



Positive direction: to the right

(a) Write the displacement from O to A and from O to B as signed numbers.

(b) Can a 2D vector be written as one signed number? Why or why not?

3. Decide whether each direction is real (R), fake (F) or there is no direction (N).

_____ (1) the direction of velocity _____ (2) the direction of current

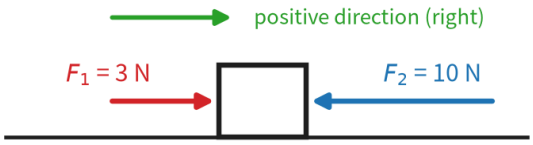
_____ (3) mass _____ (4) "I'm aiming for a score of 90"

Current flows from the positive to the negative pole, so why is it a scalar?

4. Which use of the + and − signs is each case? Write 1, 2 or 3 (see "Three uses" on page 1).

_____ (a) the poles of a battery, + and − _____ (b) F_2 = −10 N _____ (c) −3 is smaller than +2

5. Qi Xiaoyu pushes a box to the right with F_1 = 3 N, then to the left with F_2 = 10 N. Take right as positive.



Qi Xiaoyu pushes right (F_1), then left (F_2)

(a) Write F_1 and F_2 as signed numbers. _____ _____

(b) Which force is bigger? Why?

6. True (T) or false (F)?

_____ (1) Only vectors can have + or − signs.

_____ (2) A + or − sign always shows the size of a quantity.

_____ (3) Some scalars have a direction, but it is always a fake direction.

_____ (4) A scalar can have a real direction.

_____ (5) Any vector, 1D or 2D, can be written as one signed number.

_____ (6) −10 N is a bigger force than +3 N.

Answers and explanations

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

1. **(1) V** **(2) V** **(3) S** **(4) S** **(5) S** **(6) V**
Velocity, force and displacement have both magnitude and direction, so they are vectors. Mass, volume and temperature have magnitude only, so they are scalars.
▶ **Watch 1:03, Example 1**

2. (a) x_{OA} = **+3 m**; x_{OB} = **−2 m**.
O to A points right (positive) and is 3 m long, so +3 m. O to B points left (negative) and is 2 m long, so −2 m.
(b) No. A 2D vector has endless directions, and + and − can only show two. Only 1D vectors can be written as a signed number.
▶ **Watch 3:26, Example 2**

3. **(1) R** **(2) F** **(3) N** **(4) F**
Velocity: "37.5° south of east" sounds fine, so the direction is real. Current: it sounds odd, so the direction is fake. Mass has no direction at all. A score of 90 is called a direction, but you can't say east, west, south or north.
Current: its direction is fake (positive to negative pole, not a direction in space). A scalar can have a fake direction. Only vectors have real directions, so current is a scalar.
▶ **Watch 7:07, Example 3**

4. **(a) 3** **(b) 2** **(c) 1**
(a) The poles of a battery are just two names, + and −: two values of one property. (b) The sign shows direction: opposite to the positive direction. (c) The sign shows order of size.
▶ **Watch 9:36, Example 4**

5. (a) $\mathbf{F_1}$ **= +3 N** (same direction as +), $\mathbf{F_2}$ **= −10 N** (opposite to +).
(b) F_2 is bigger. When comparing vectors, ignore the sign and compare the numbers: 10 N > 3 N.
▶ **Watch 10:05, Example 5**

6. **(1) F** **(2) F** **(3) T** **(4) F** **(5) F** **(6) T**
(1) A battery's poles and temperatures have signs too, and they are not vectors. (2) A sign need not show size, e.g. a battery's poles. (4) A scalar's direction is always fake. (5) Only 1D vectors. (6) Compare the numbers: 10 N is more than 3 N.
▶ **Watch 12:33, Example 6**

One-line summary

Vector: arrow, real direction. Scalar: a number. A 1D vector is a signed number, and when you compare sizes you ignore the sign.

Key terms

Term	Meaning	Chinese
vector	has magnitude and a real direction	矢量 shǐliàng
scalar	has magnitude only, written as a number	标量 biāoliàng
1D vector	a vector with only two directions	一维矢量 yīwéi shǐliàng
vector algebraization	writing a 1D vector as a signed number	矢量代数化 shǐliàng dàishùhuà
positive direction	the direction we choose to call +	正方向 zhèngfāngxiàng
real / fake direction	a direction you can / can't call east, west, south or north	真方向 / 假方向 zhēn fāngxiàng / jiǎ fāngxiàng
displacement	a vector from the start to the end	位移 wèiyí
current	flow of electric charge (a scalar)	电流 diànliú