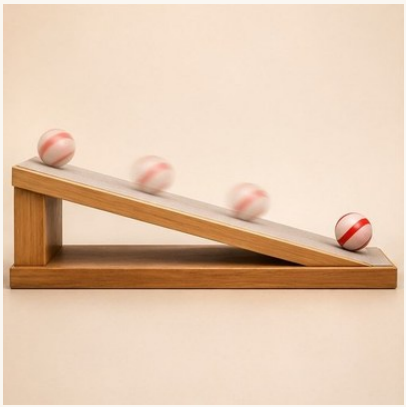
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Describing and predicting motion





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02 A complete return

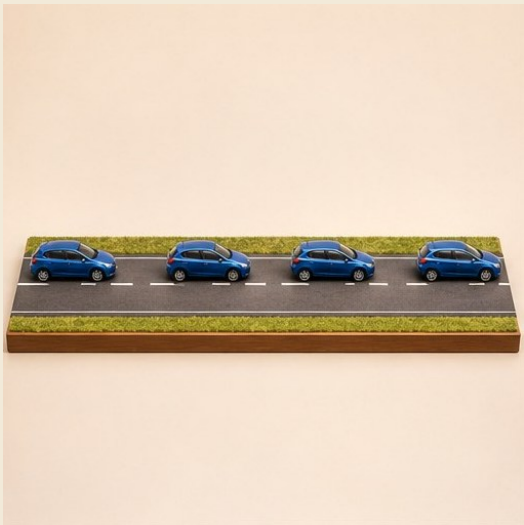
03 Start and speed up

04 Two messages in a velocity graph

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Describing and predicting motion

Motion needs a reference



THE IDEA

Position is measured relative to something. A seated passenger is at rest relative to the bus but moving relative to the road.

Choose an origin and positive direction before describing straight-line motion. Then positions can be positive or negative.

CHECK YOUR THINKING

What must be stated when describing position?

A Only the object's colour.

B A reference point and direction.

B. Motion and position depend on the chosen reference frame.

A RELATED EXAMPLE

The route and the change

Distance and displacement answer different questions. Distance adds the length of the whole route. Displacement is final position minus initial position, with direction. A return to the start has zero displacement even after a long journey. Distance cannot be negative.

Describing and predicting motion

A complete return

Out and back in 60 s

Outward leg	120 m
Return leg	120 m
Finish	At the start

THE IDEA

A runner goes 120 m out and 120 m back in 60 s. Find total distance, then divide by time. Separately find displacement and average velocity.

Explain why the two averages differ even though they describe the same run.

CHECK YOUR THINKING

What are average speed and average velocity?

A 4 m/s and 0 m/s.

B Both 4 m/s.

A. Distance is 240 m; displacement is zero. Divide each by the same 60 s.

A RELATED EXAMPLE

Out and back

Choose east as positive. A walker goes 80 m east, then 30 m west. Distance = 80 + 30 = 110 m. Displacement = 80 − 30 = 50 m east. Adding the route and comparing endpoints are different operations.

Describing and predicting motion

Start and speed up

Speed at each time

At 0 s — **2 m/s**

At 4 s — **10 m/s**

THE IDEA

Keep the signs and units visible. A trolley changes from 2 m/s to 10 m/s in 4 s. $a = (10 - 2)/4 = 2$ m/s².

If acceleration is constant, velocity increases by 2 m/s each second. That is not a distance of 2 m each second.

CHECK YOUR THINKING

What is the acceleration in this example?

A 2 m/s².

B 3 m/s².

A. Subtract the initial velocity before dividing by elapsed time.

A RELATED EXAMPLE

A change in velocity

Acceleration includes changes in direction. For straight-line motion, average acceleration $a = (v - u)/t$. Its unit is m/s². A negative acceleration points in the chosen negative direction. It may speed up a negatively moving object, not always slow it down.

Describing and predicting motion

Two messages in a velocity graph



THE IDEA

Slope gives acceleration; signed area gives displacement. On a velocity-time graph, a horizontal line means constant velocity, not necessarily rest.

Area above the time axis contributes positive displacement; area below contributes negative displacement.

CHECK YOUR THINKING

What gives displacement from a velocity-time graph?

A The signed area under the line. B Only the line's slope.

A. Slope gives acceleration; multiplying velocity by time gives displacement.

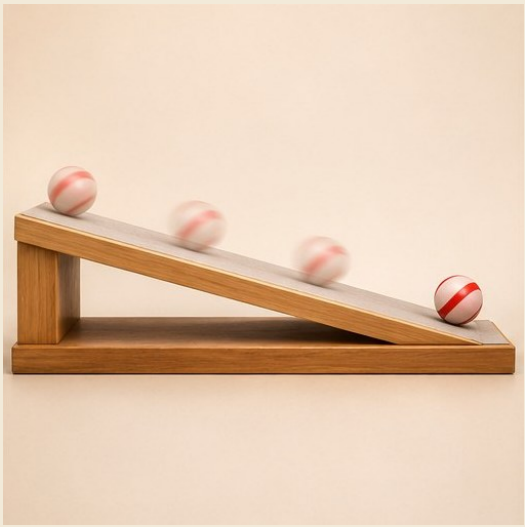
A RELATED EXAMPLE

The slope tells a story

Position-time slope is velocity. A straight rising line shows constant positive velocity. A horizontal line shows constant position. A steeper slope means a larger velocity magnitude. A curved line means the slope, and therefore velocity, changes.

Describing and predicting motion

Choose an equation with a reason



THE IDEA

These equations require constant acceleration. $v = u + at$ links velocity and time. $s = ut + \frac{1}{2}at^2$ gives displacement.

$v^2 - u^2 = 2as$ is useful when time is absent. Use one consistent positive direction and SI units.

CHECK YOUR THINKING

Which condition is required?

A The object must start at rest.

B Acceleration remains constant over the interval.

B. A nonzero initial velocity is allowed; constant acceleration is the key condition.

A RELATED EXAMPLE

Split the graph

Move at 3 m/s for 4 s, then 6 m/s for 2 s. Imagine two rectangles on a velocity-time graph. Find each area and add them. Calculate average velocity using the combined displacement and the full 6 seconds.

ONE LAST CHALLENGE

What are the average speed and average velocity?

A runner completes one 400 m lap in 80 s and finishes at the starting line.



THE REVEAL

5 m/s and 0 m/s.

Speed uses 400 ÷ 80. Average velocity uses displacement, which is zero after a complete lap.

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