Reference Frames

If you are floating in empty space, and you see a fellow floater approaching you, how do you know which one of you is moving?

Reference Frames

A "Reference Frame", or zero-point, or origin, *must always be chosen* in order to apply a mathematical model to a physical situation.

Distance vs. Displacement

Let $x(t)$ be the position of a particle (or "body") at time t.

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$$x(0) = 0$$
$$x(1) = 20 \text{ m}$$
$$x(2) = 10 \text{ m}$$

Distance vs. Displacement

Let $x(t)$ be the position of a particle (or "body") at time t.
For some body,

$$x(0) = 0$$
$$x(1) = 20 \text{ m}$$
$$x(2) = 10 \text{ m}$$

The *displacement* of this body is 10 m, while the total distance it traveled is 30 m.

Average Velocity vs. Average Speed

Same body:

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What is the average velocity and the average speed in the time interval $t = 0$ to $t = 2$s?

Average Velocity vs. Average Speed

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$$x(1) = 20 \text{ m}$$
$$x(2) = 10 \text{ m}$$

What is the average velocity and the average speed in the time interval $t = 0$ to $t = 2$s?

$$\text{average speed} = \frac{\text{distance traveled}}{\text{time elapsed}}$$

$$\text{average velocity} = \frac{\text{displacement}}{\text{time elapsed}} = \frac{\text{final position - initial position}}{\text{time elapsed}}$$

Velocity vs. Speed

For a new body

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$$x(0) = 0$$
$$x(5) = -20 \text{ m}$$

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What is the average speed and velocity of this body?

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What is the average speed and velocity of this body?
Velocity is like speed, except direction matters.

Instantaneous Velocity

Average Velocity:

$$\overline{v} = \frac{\Delta x}{\Delta t}$$

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$$v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$$

$$v = \frac{dx}{dt}$$

Average Acceleration

Average Acceleration is the change in velocity divided by the change in time:

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What is the average acceleration this body?

Kinematics Equations

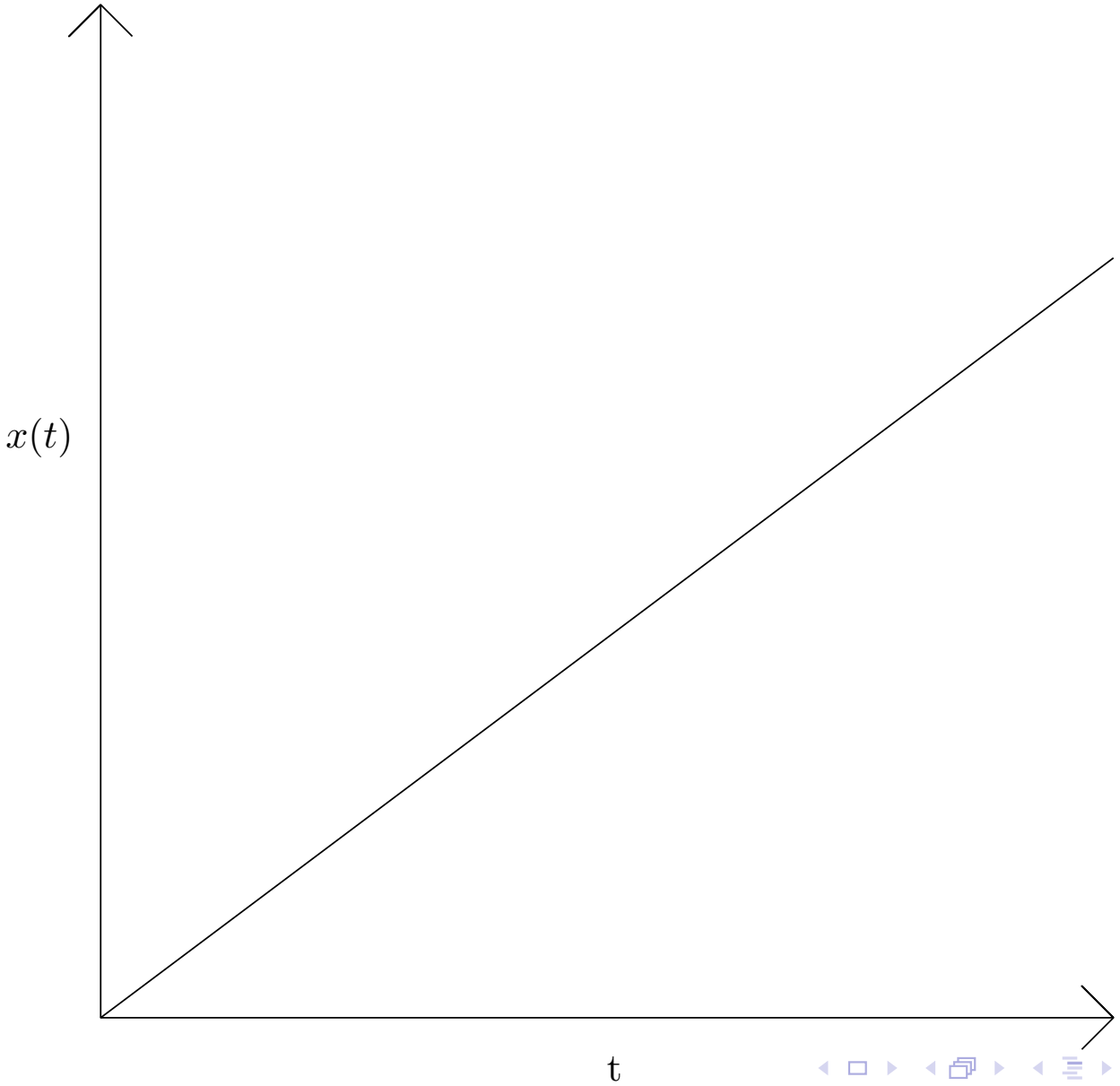
$$v = v_\circ + at$$

$$x = x_\circ + v_\circ t + \frac{1}{2}at^2$$

$$v^2 = v_\circ^2 + 2a(x - x_\circ)$$

$$\overline{v} = \frac{v + v_\circ}{2}$$

The Graph of x vs. t.



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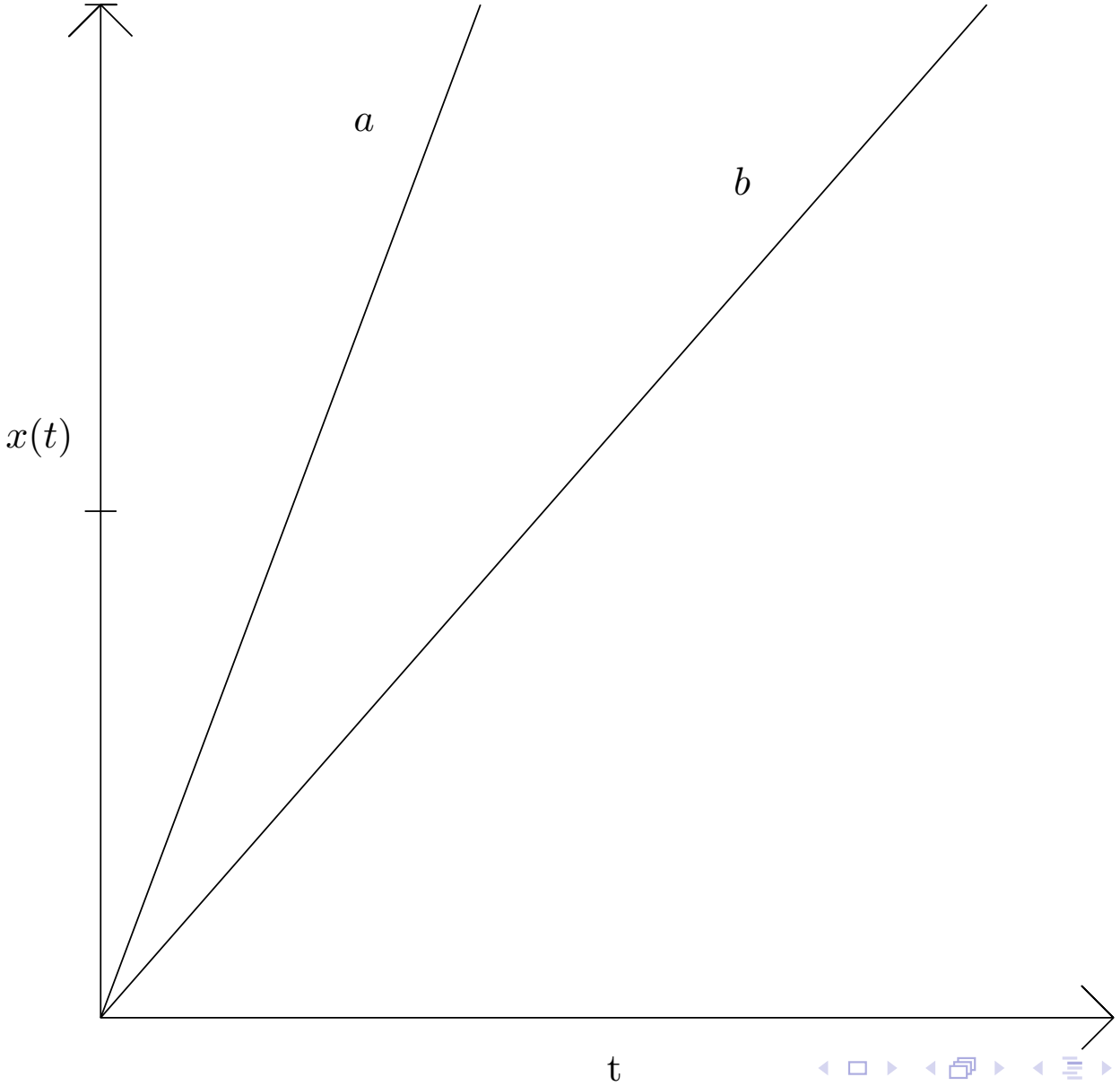

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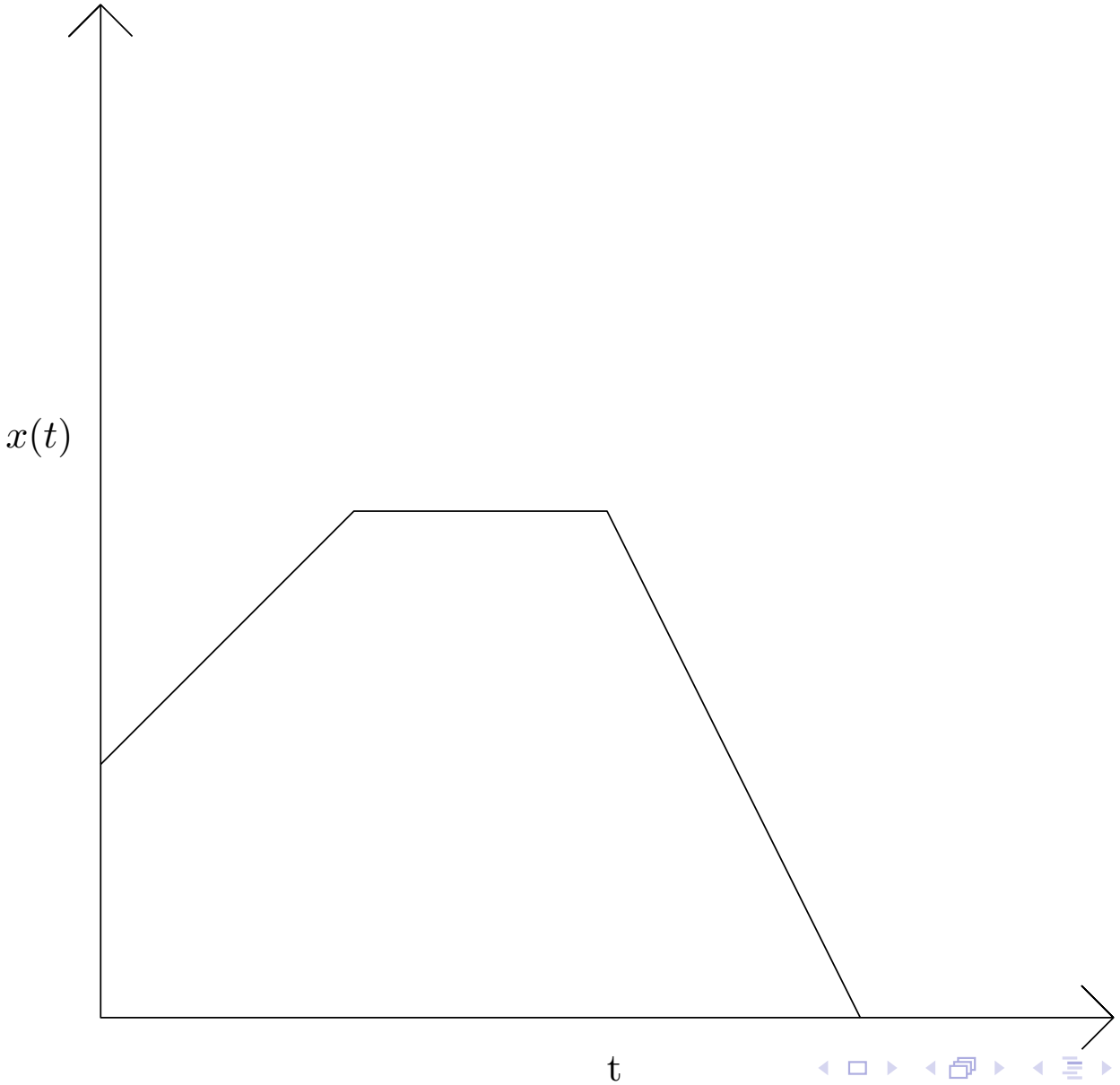

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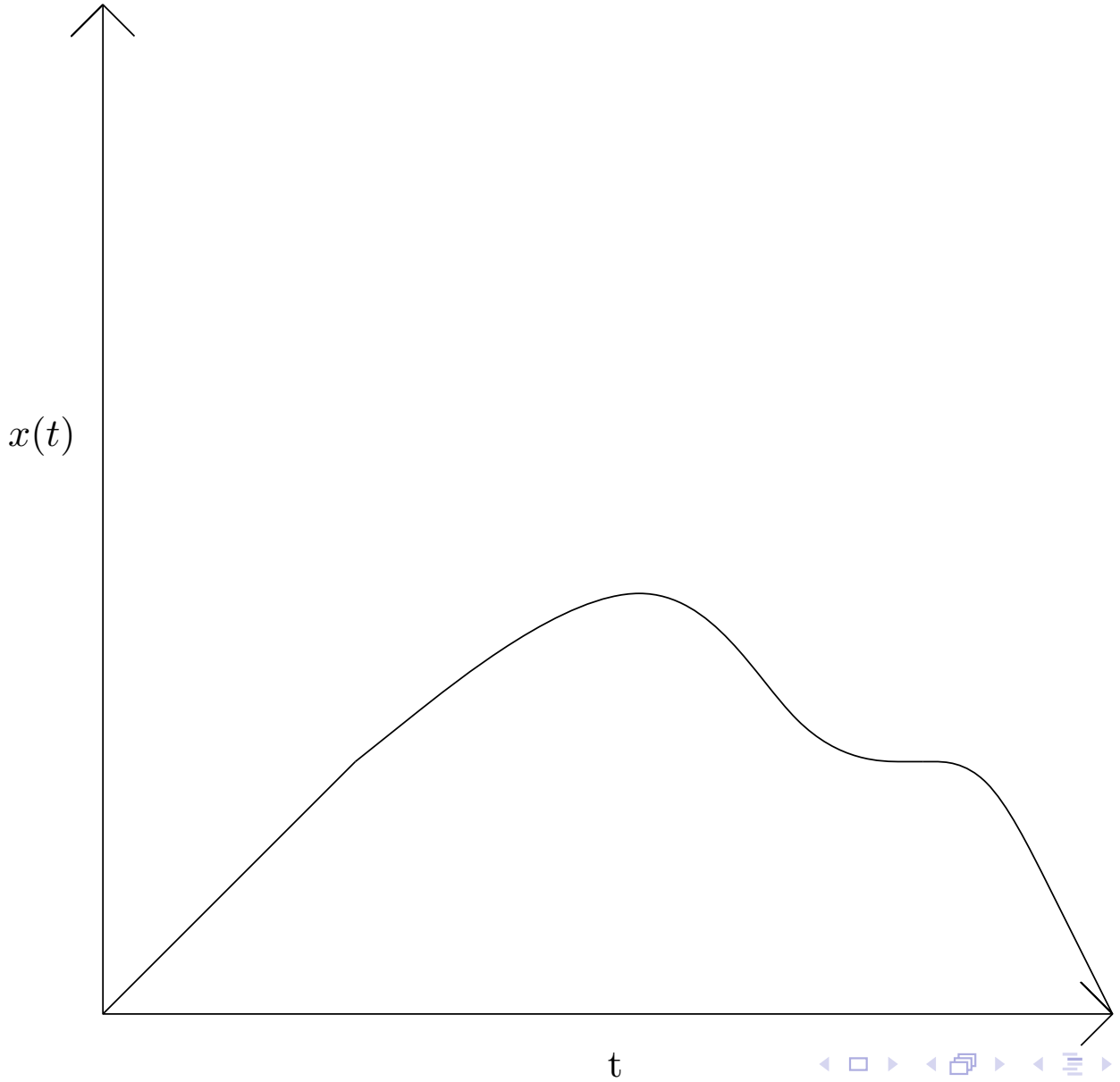
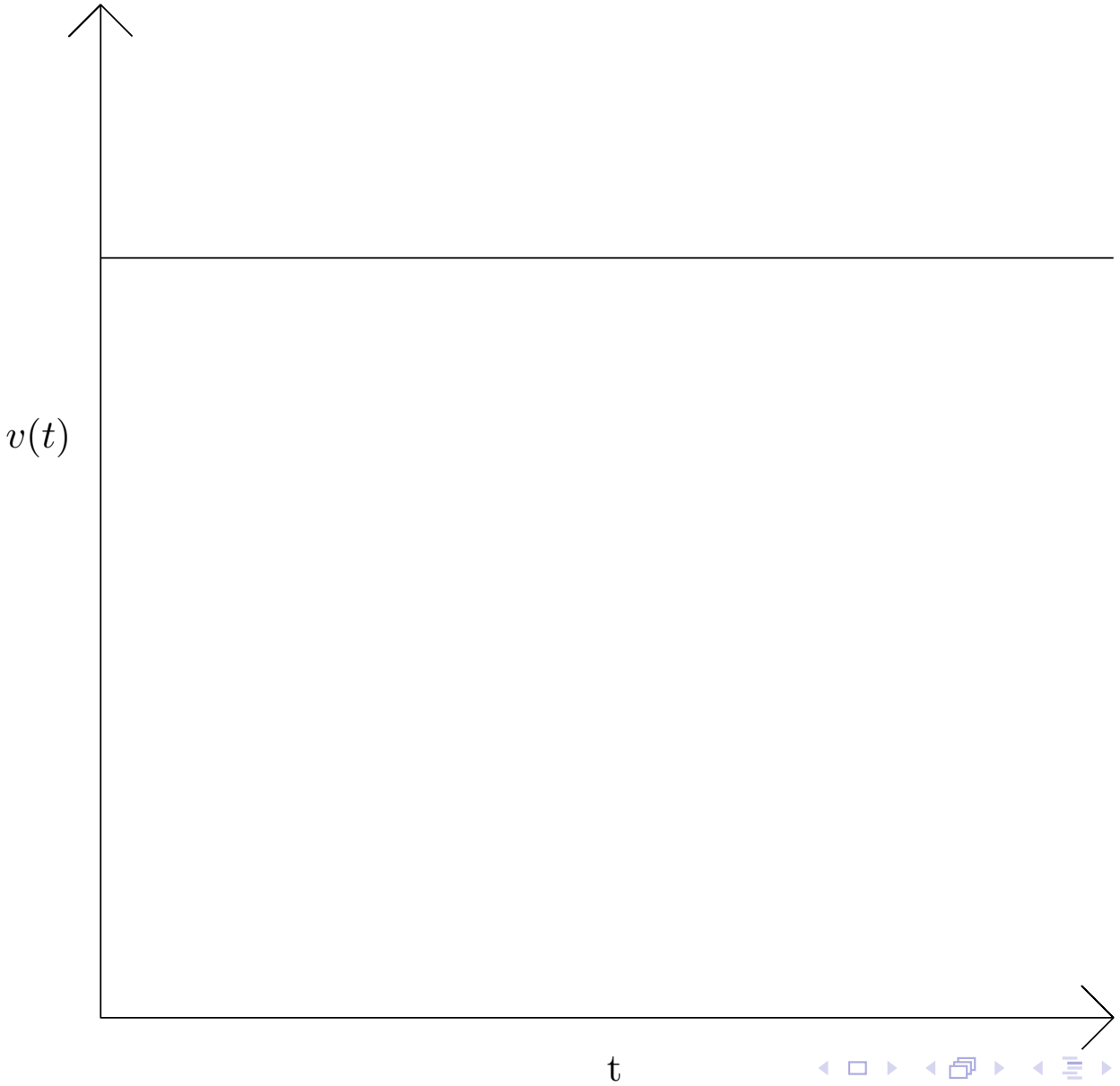
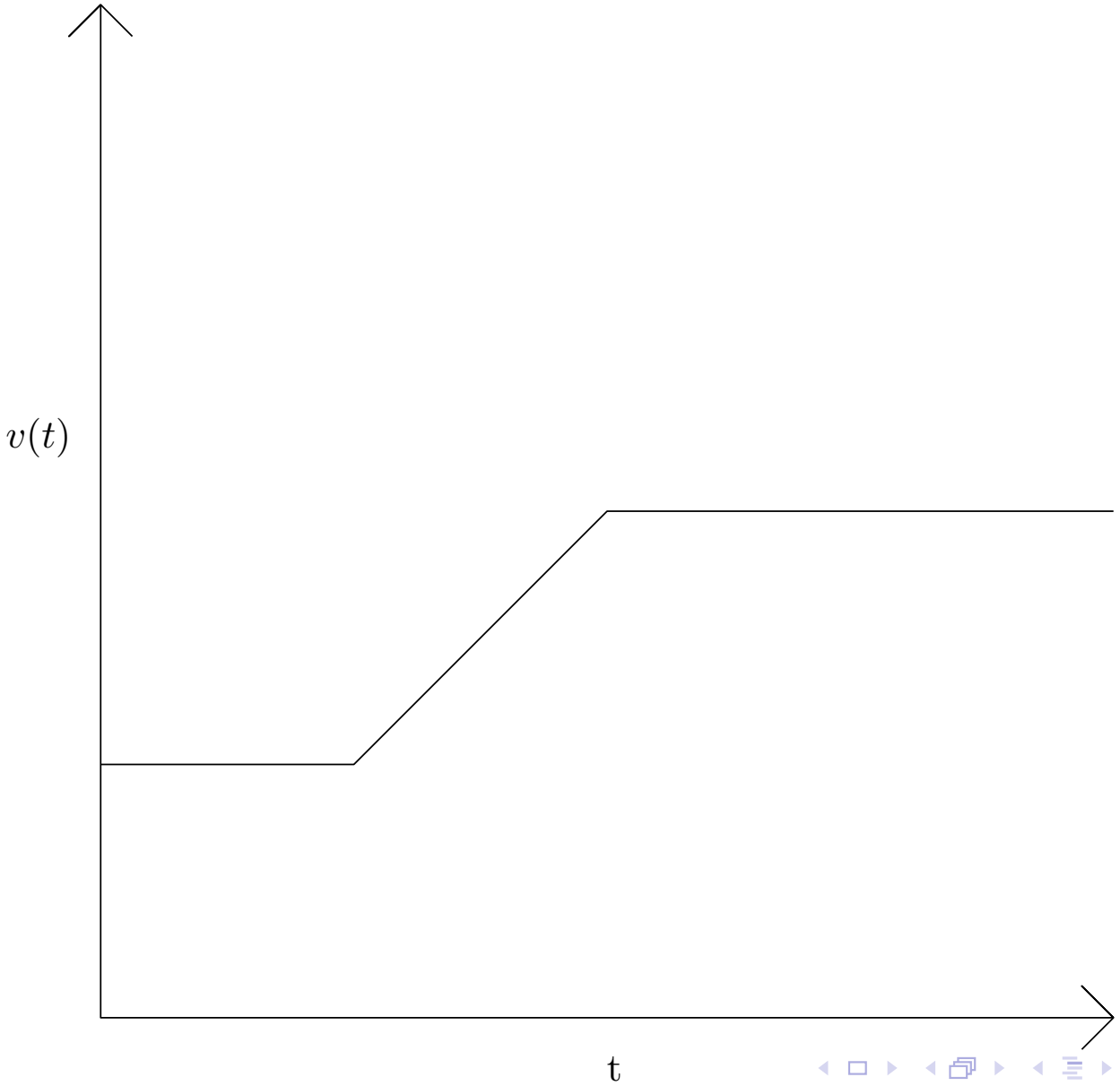


The Graph of v vs. t.



The Graph of v vs. t.



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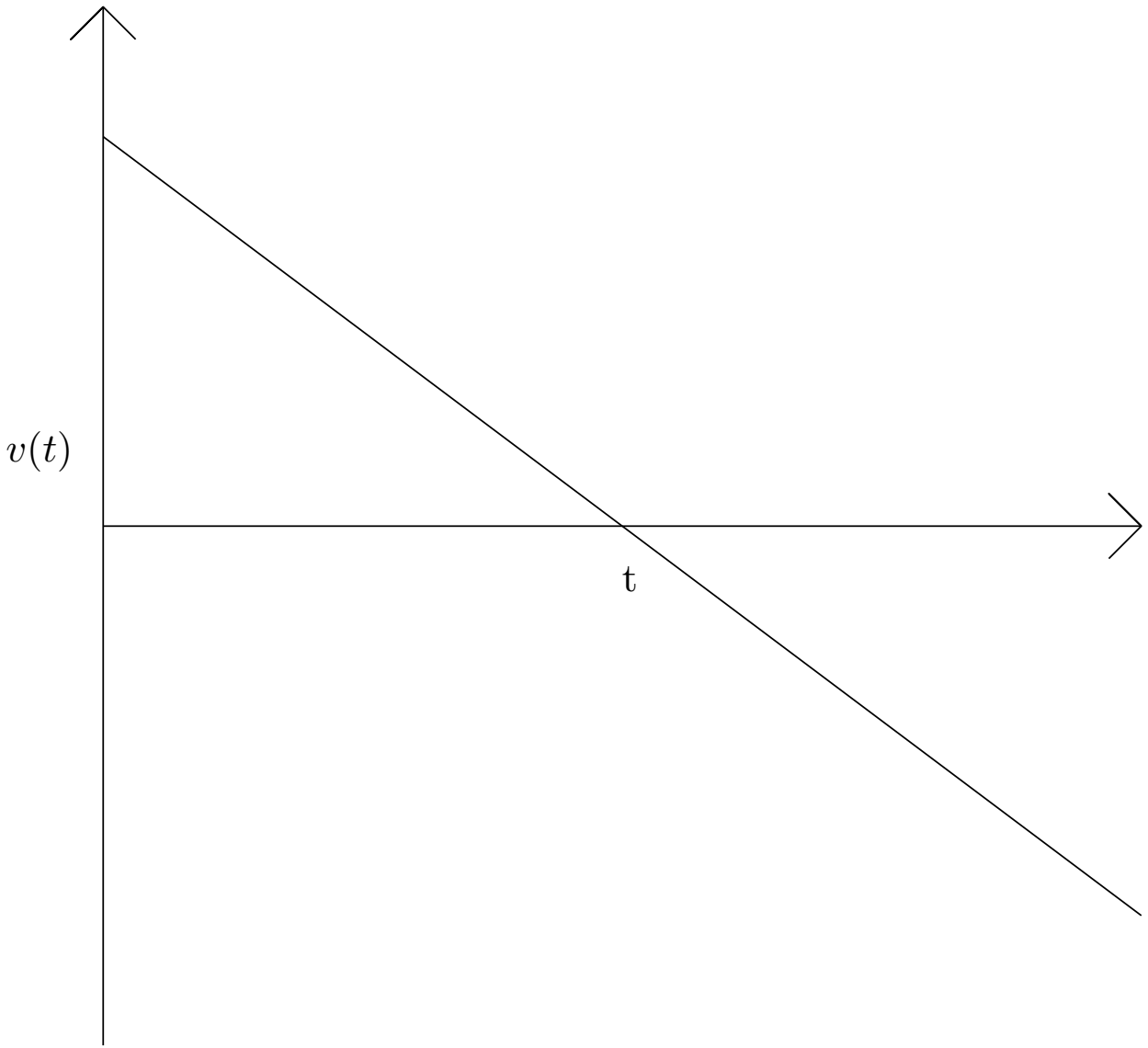

The Graph of v vs. t.