June 5, Week 1

Physics 151, Dr. Mark Morgan-Tracy

Today: Chapter 2, Acceleration

Please Register your Clicker.

Homework Assignment #1 - Due Tomorrow. Solutions will be posted tomorrow afternoon.

Mini-Test #1 on Monday, so no reading assignment.

Instantaneous velocity

When motion is no longer uniform, velocity changes with time.

Instantaneous velocity

When motion is no longer uniform, velocity changes with time.

Average Velocity:

$$v_{av} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i}$$

tells use how fast and in what direction an object went on average during the elapsed time Δt.

Instantaneous velocity

When motion is no longer uniform, velocity changes with time.

Average Velocity:

$$v_{av} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i}$$

tells use how fast and in what direction an object went on average during the elapsed time Δt.

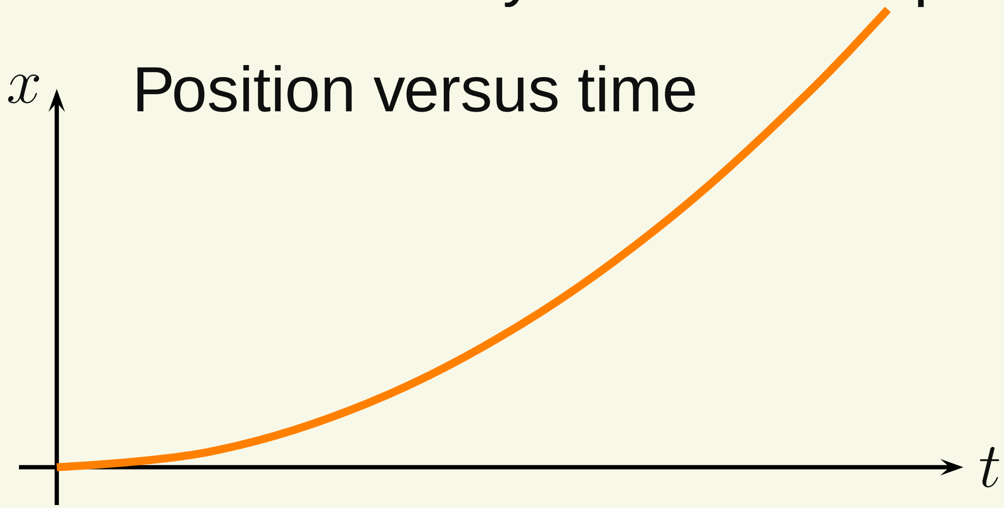
Instantaneous velocity, v_x - How fast and in what direction for one instant of time t.

Changing Velocity

When velocity is changing, position versus time is now a curve. Instantaneous velocity is still the slope of the graph.

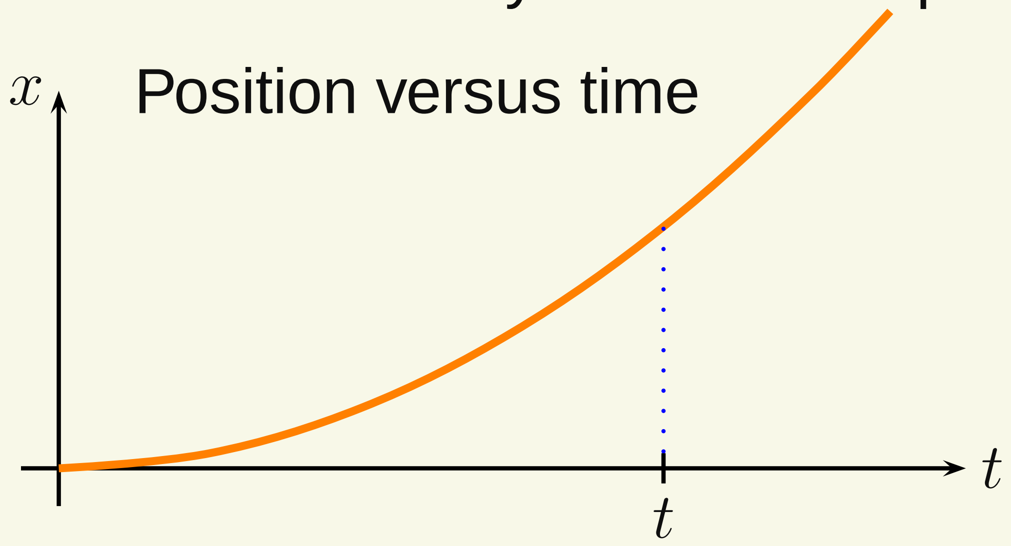
Changing Velocity

When velocity is changing, position versus time is now a curve.
Instantaneous velocity is still the slope of the graph.



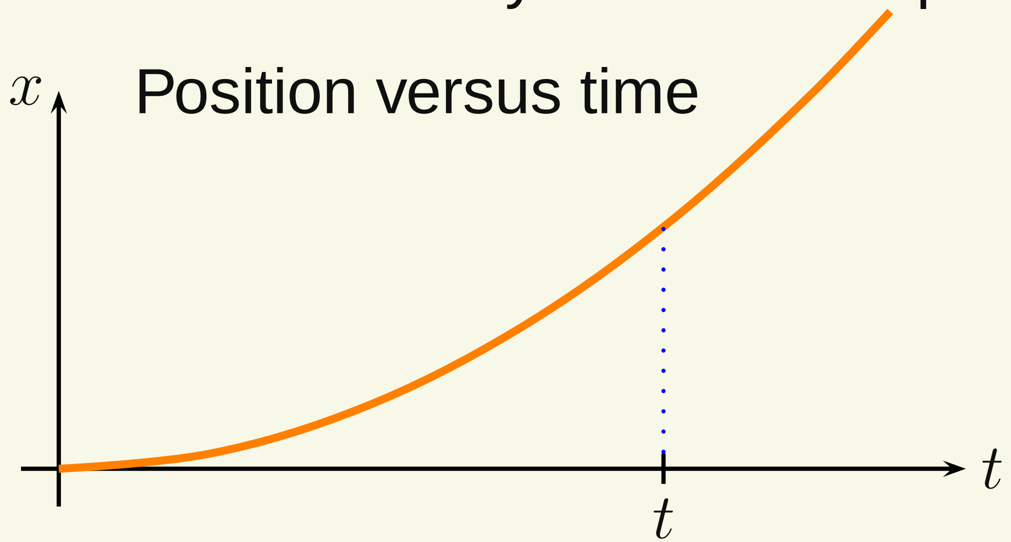
Changing Velocity

When velocity is changing, position versus time is now a curve. Instantaneous velocity is still the slope of the graph.



Changing Velocity

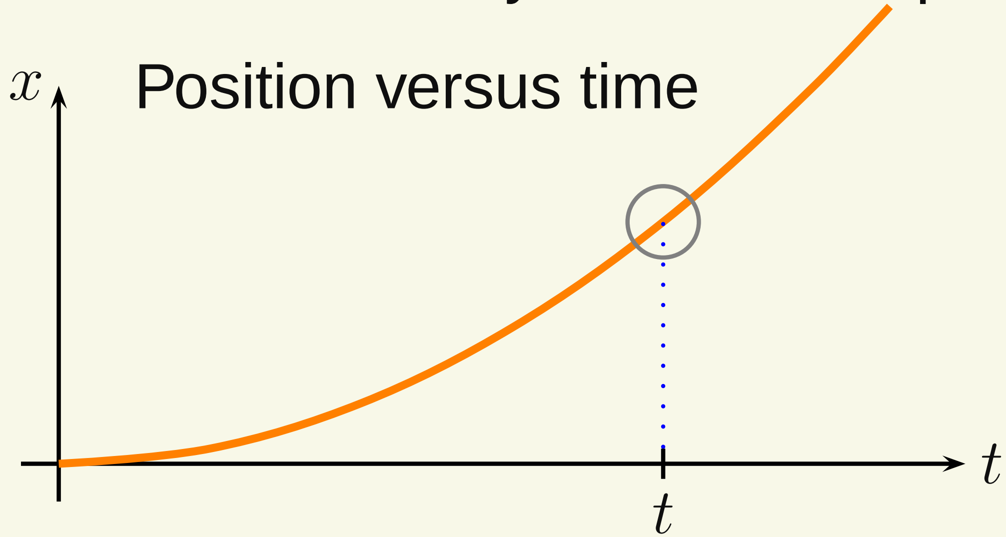
When velocity is changing, position versus time is now a curve. Instantaneous velocity is still the slope of the graph.



To find the velocity at one time t we use the fact that all curves look straight when magnified

Changing Velocity

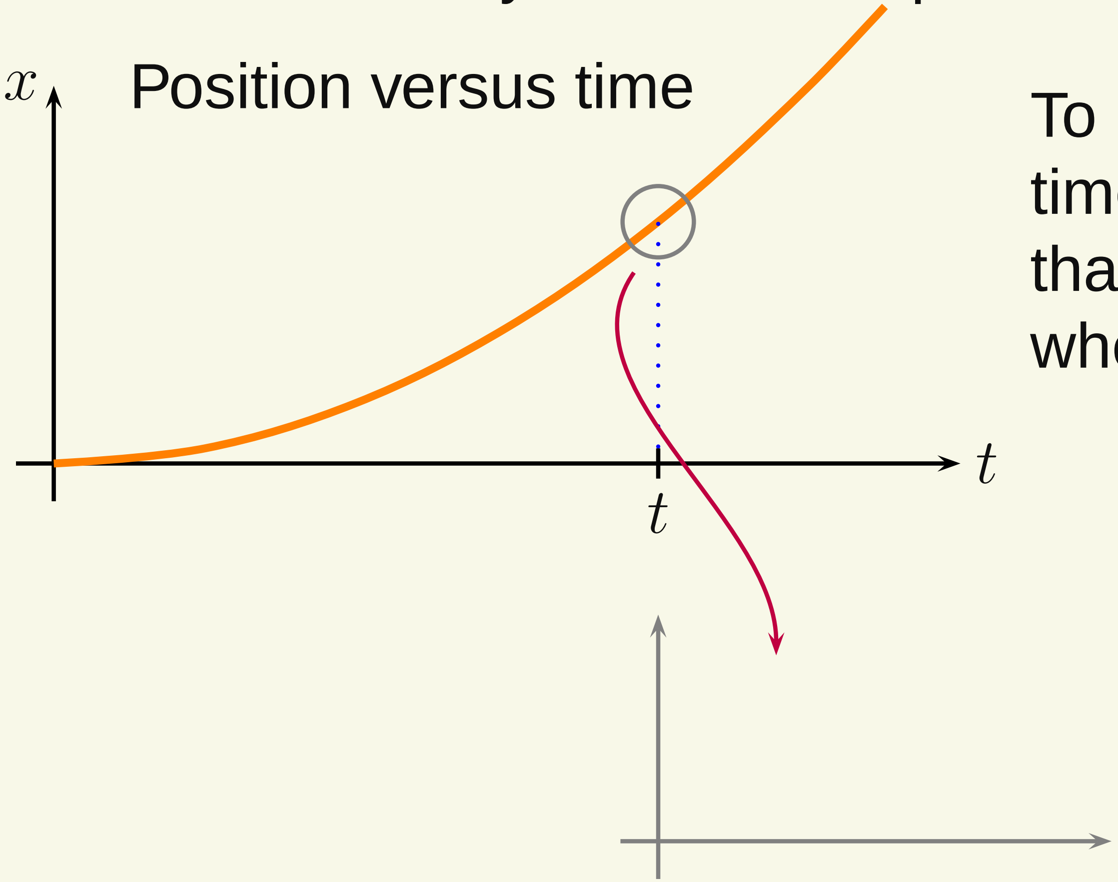
When velocity is changing, position versus time is now a curve. Instantaneous velocity is still the slope of the graph.



To find the velocity at one time t we use the fact that all curves look straight when magnified

Changing Velocity

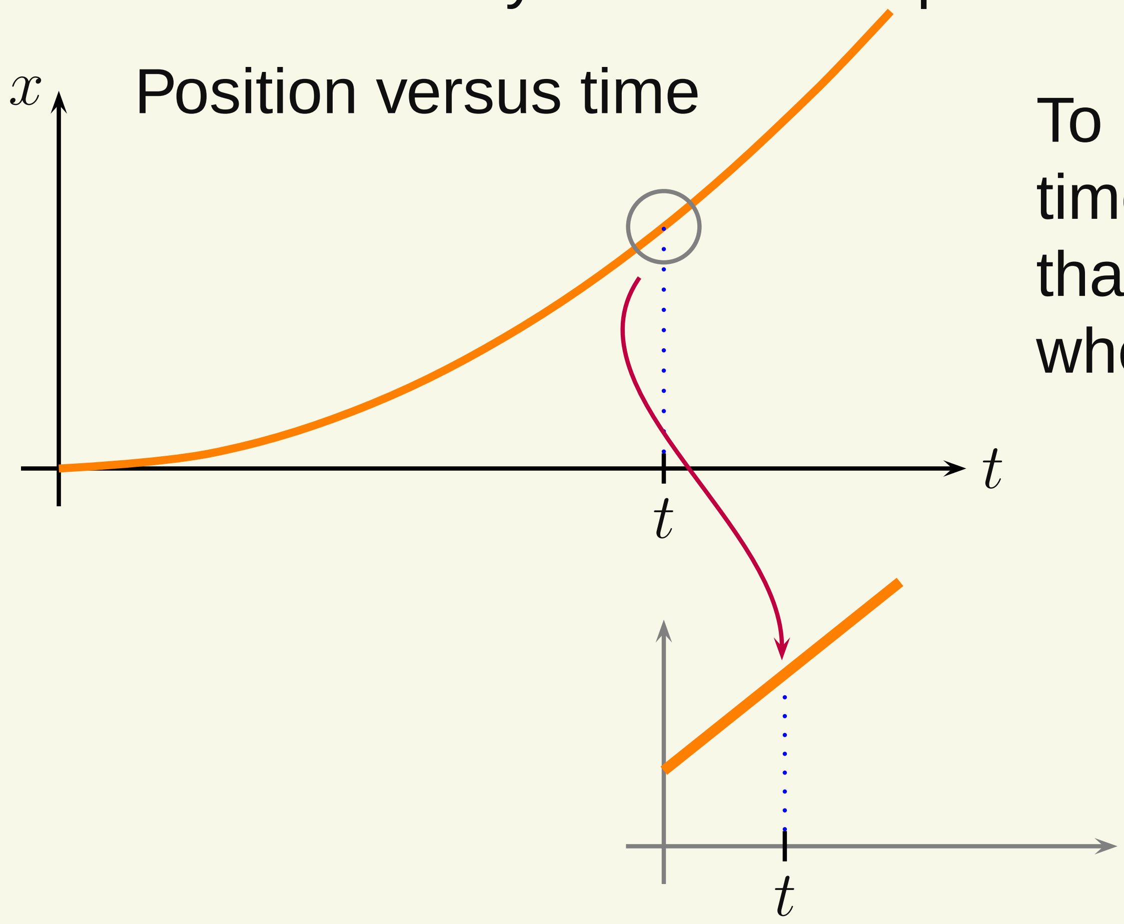
When velocity is changing, position versus time is now a curve.
Instantaneous velocity is still the slope of the graph.



To find the velocity at one time t we use the fact that all curves look straight when magnified

Changing Velocity

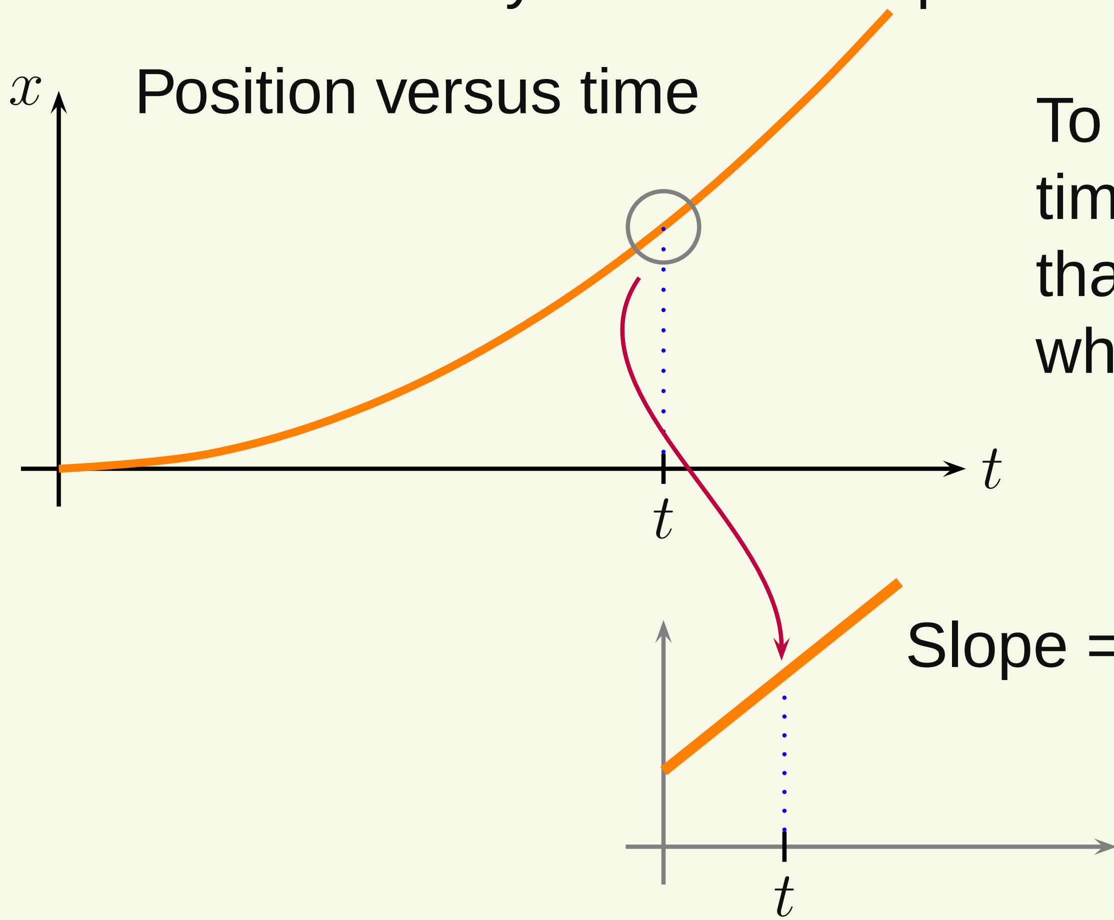
When velocity is changing, position versus time is now a curve. Instantaneous velocity is still the slope of the graph.



To find the velocity at one time t we use the fact that all curves look straight when magnified

Changing Velocity

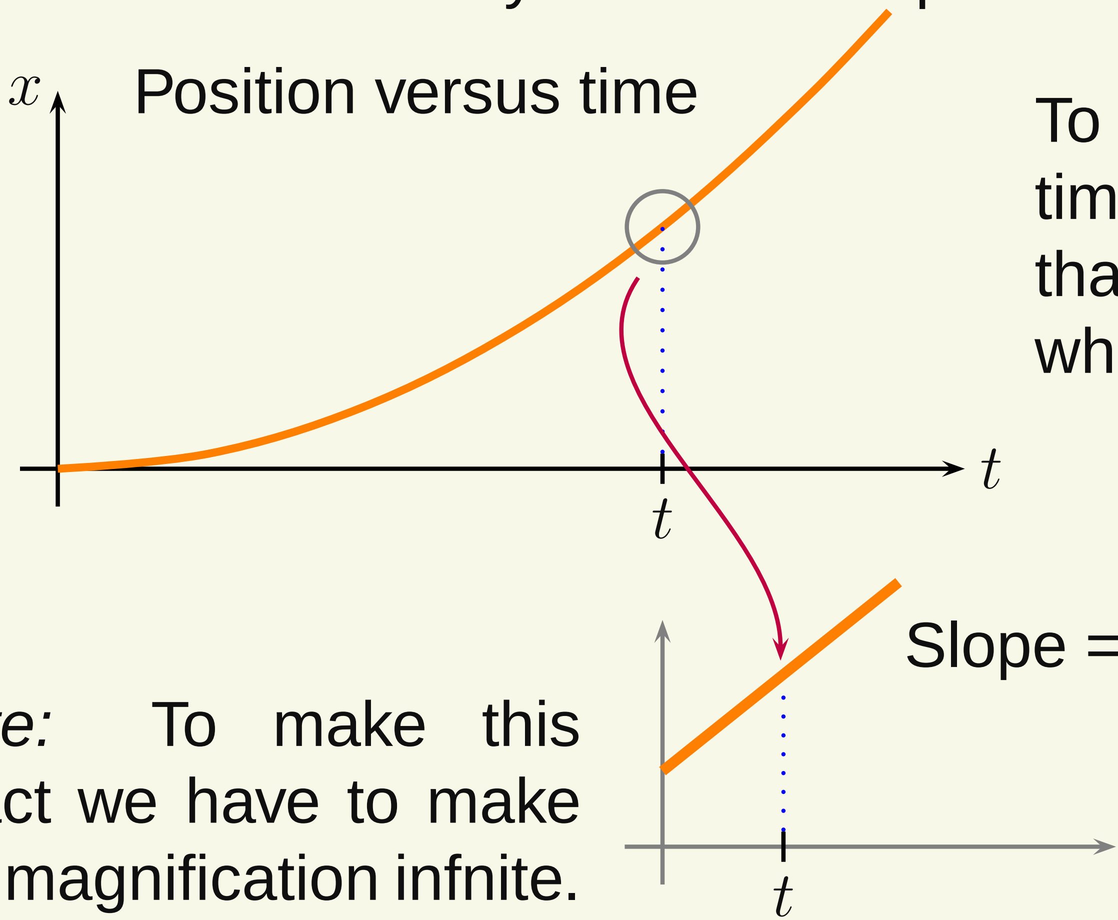
When velocity is changing, position versus time is now a curve.
Instantaneous velocity is still the slope of the graph.



To find the velocity at one time t we use the fact that all curves look straight when magnified

Changing Velocity

When velocity is changing, position versus time is now a curve. Instantaneous velocity is still the slope of the graph.



To find the velocity at one time t we use the fact that all curves look straight when magnified

Slope = Velocity at time t

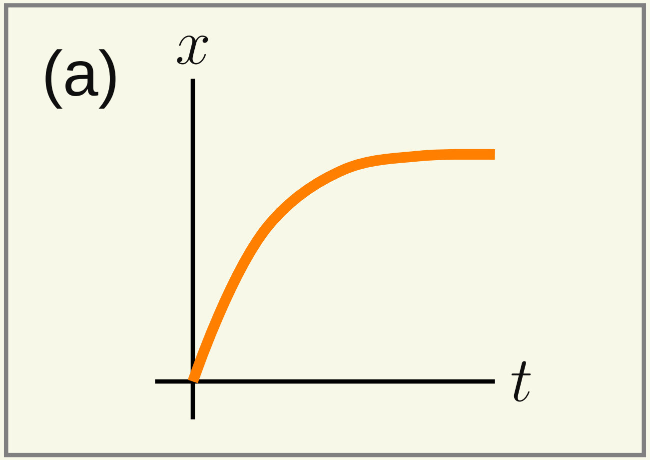
Note: To make this exact we have to make the magnification infnite. In calculus, this is called taking a derivative.

Velocity Exercise I

Which of the following position versus time graphs corresponds to an object which is slowing down?

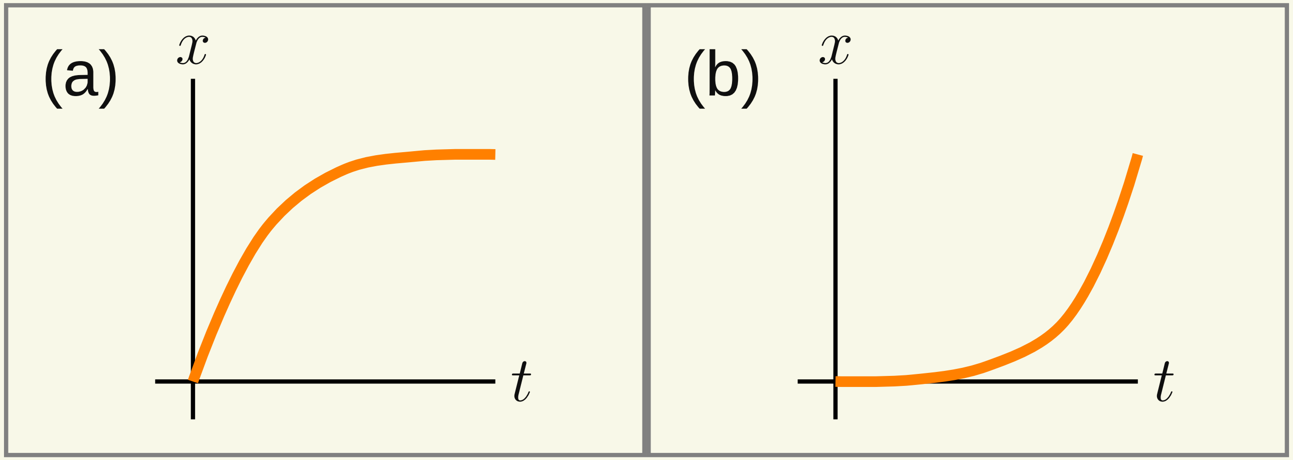
Velocity Exercise I

Which of the following position versus time graphs corresponds to an object which is slowing down?



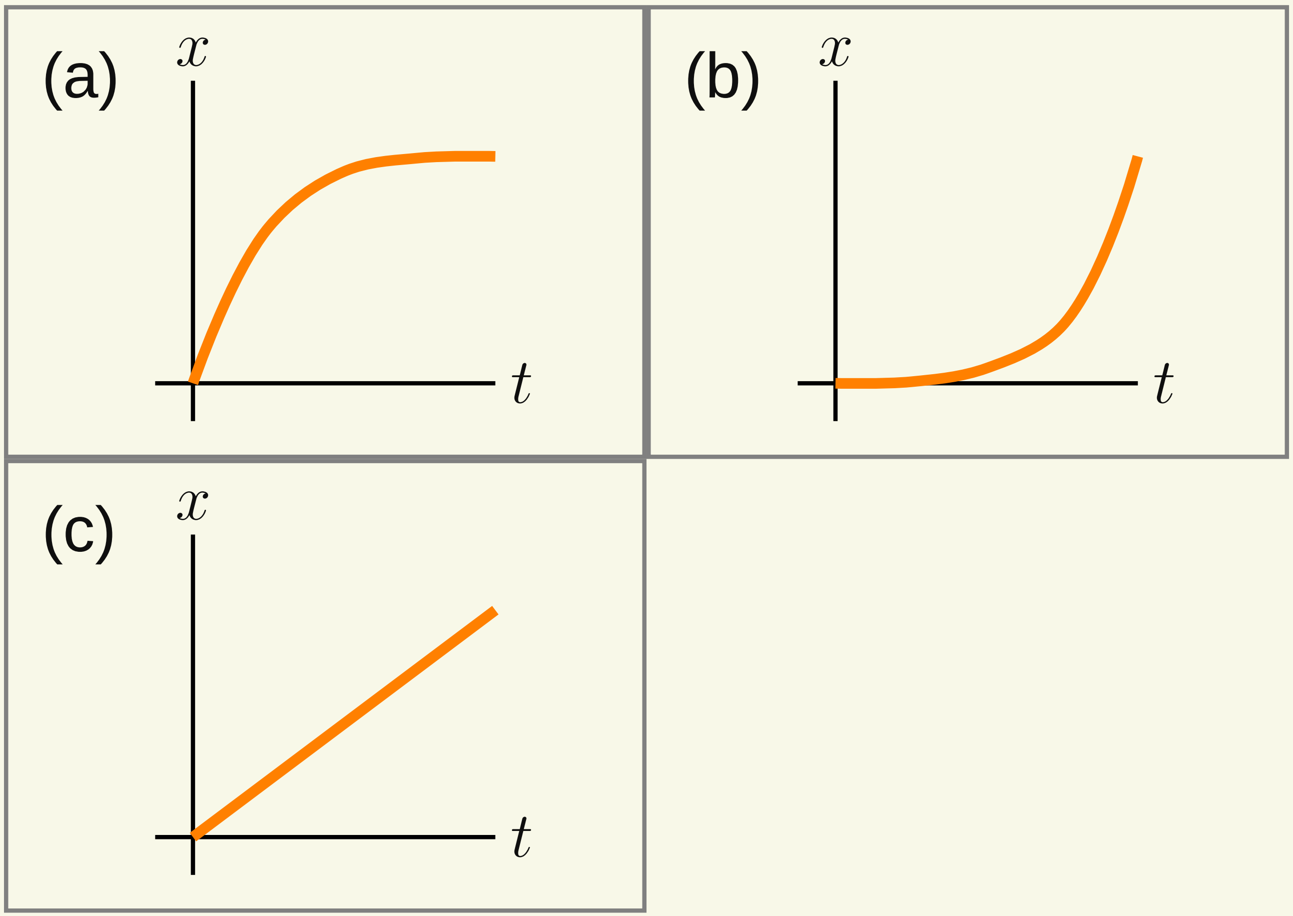
Velocity Exercise I

Which of the following position versus time graphs corresponds to an object which is slowing down?



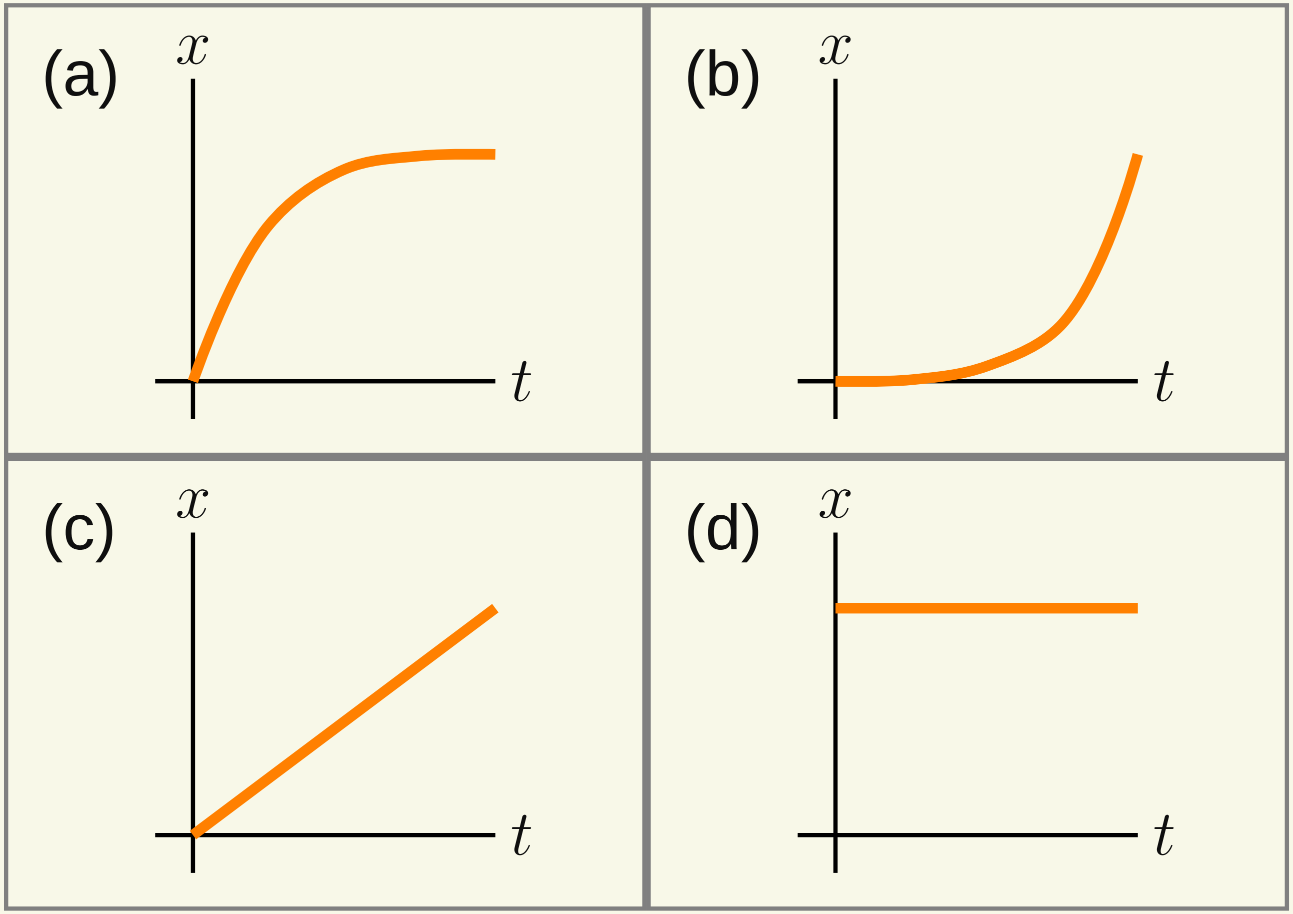
Velocity Exercise I

Which of the following position versus time graphs corresponds to an object which is slowing down?



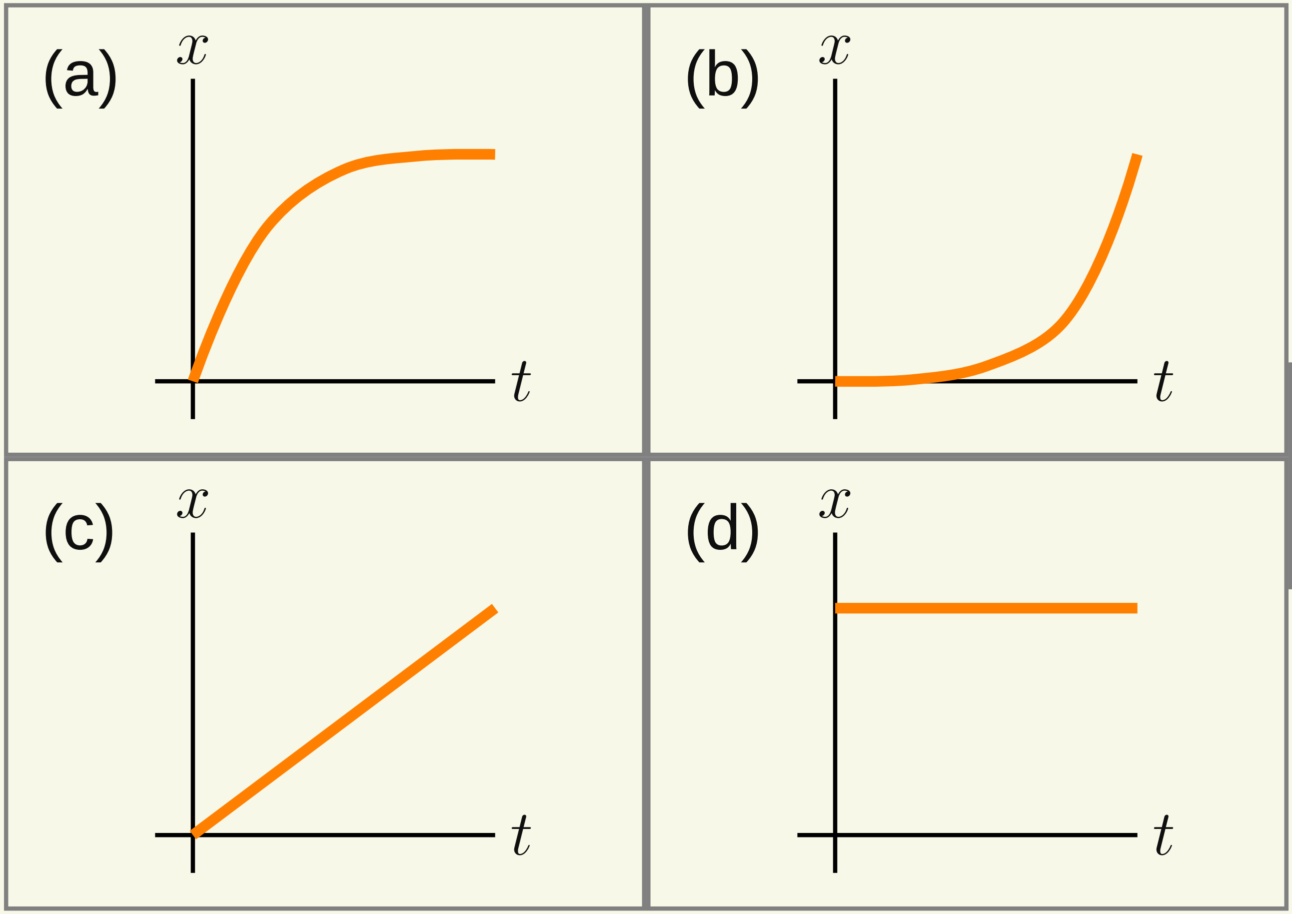
Velocity Exercise I

Which of the following position versus time graphs corresponds to an object which is slowing down?



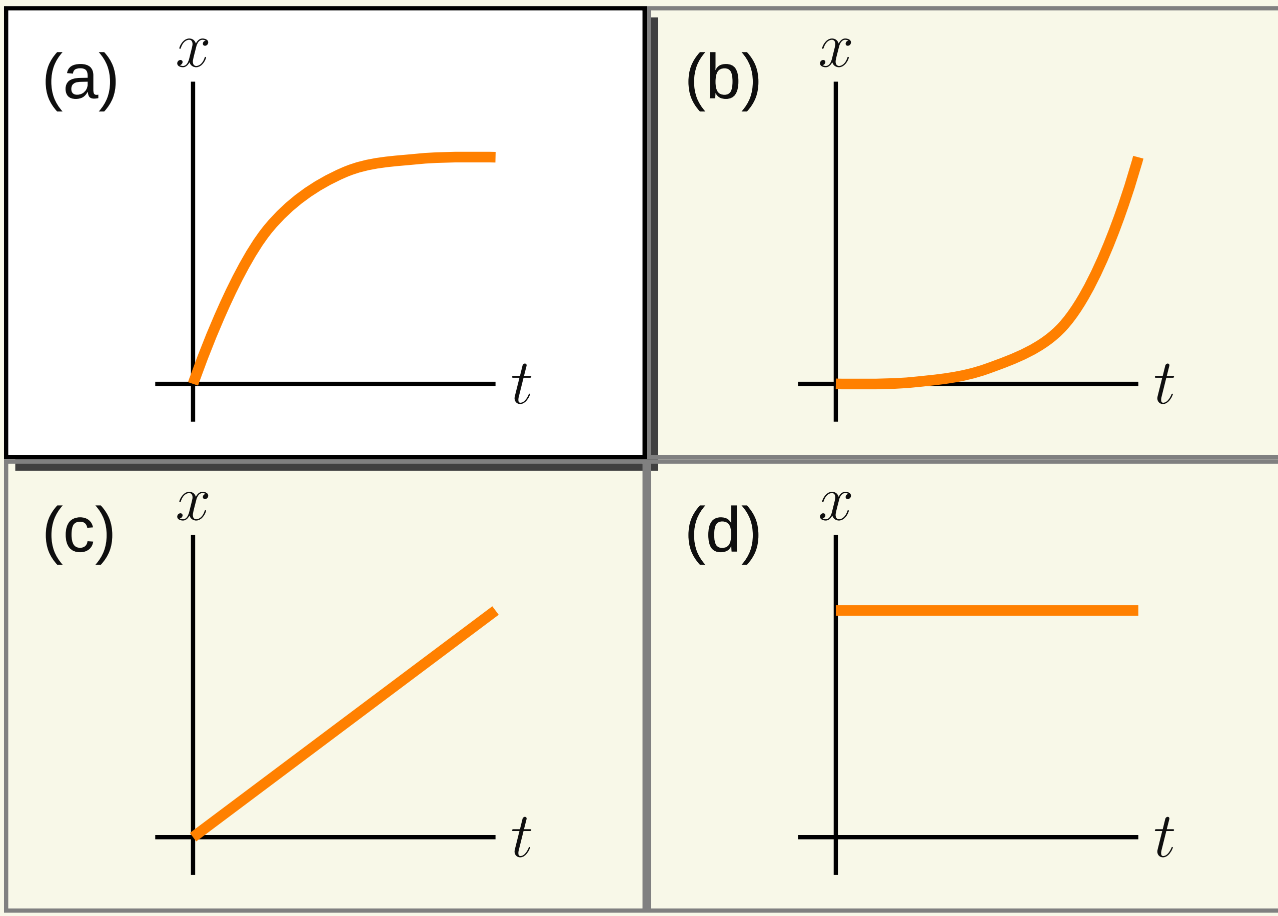
Velocity Exercise I

Which of the following position versus time graphs corresponds to an object which is slowing down?



(e) None of these

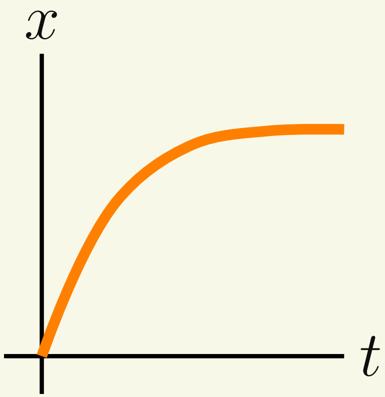
Which of the following position versus time graphs corresponds to an object which is slowing down?



(e) None of these

Velocity Followup

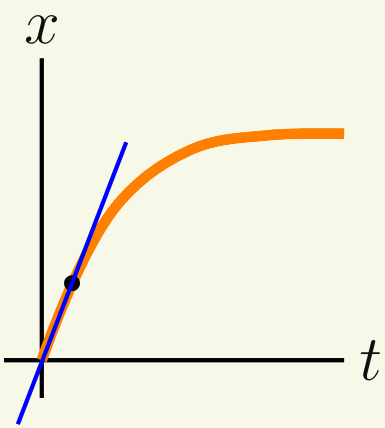
(a)



Slowing Down

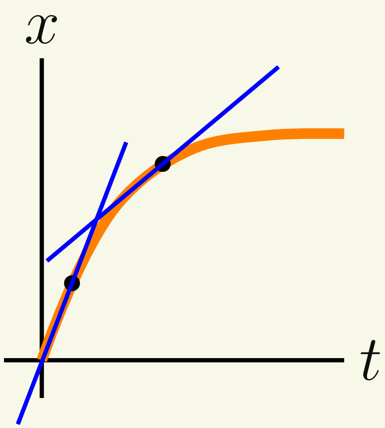
Velocity Followup

(a)



Slowing Down

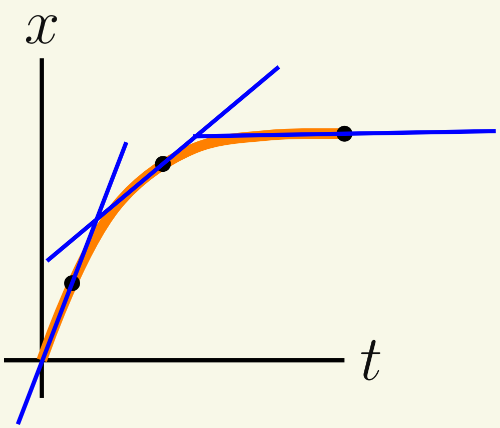
Velocity Followup

(a) 

Slowing Down

Velocity Followup

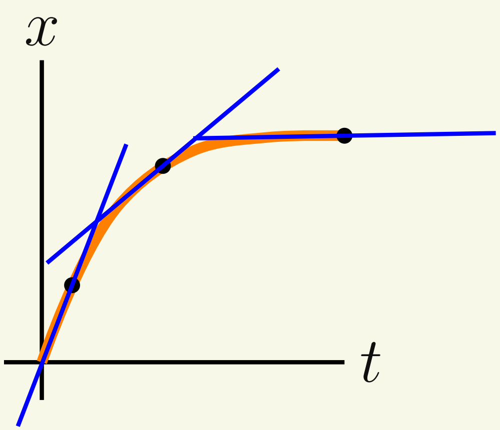
(a)



Slowing Down

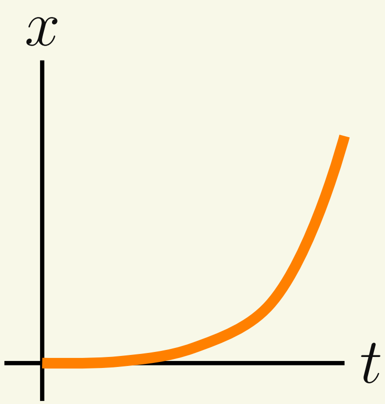
Velocity Followup

(a)



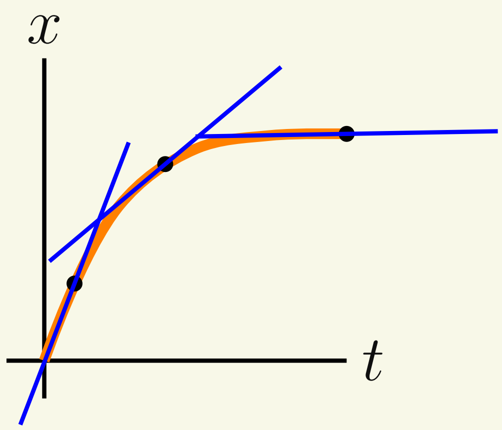
Slowing Down

(b)



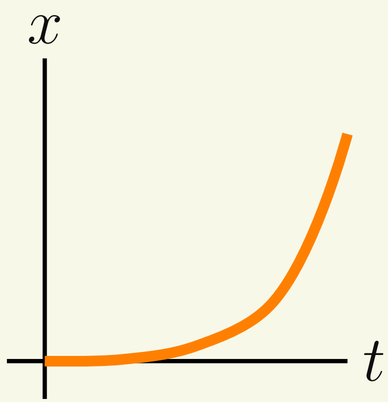
Velocity Followup

(a)



Slowing Down

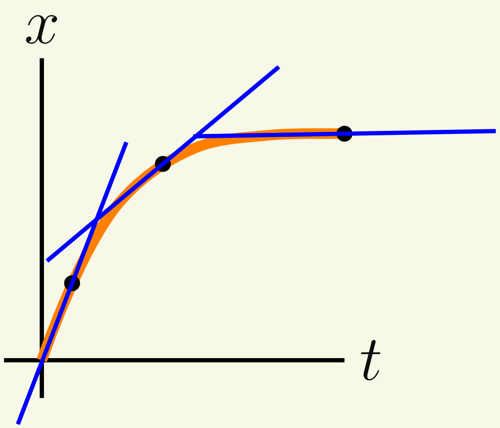
(b)



Speeding Up

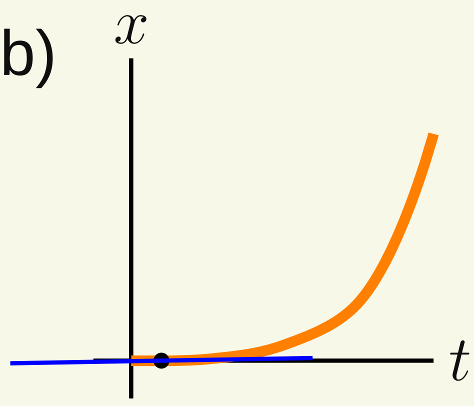
Velocity Followup

(a)



Slowing Down

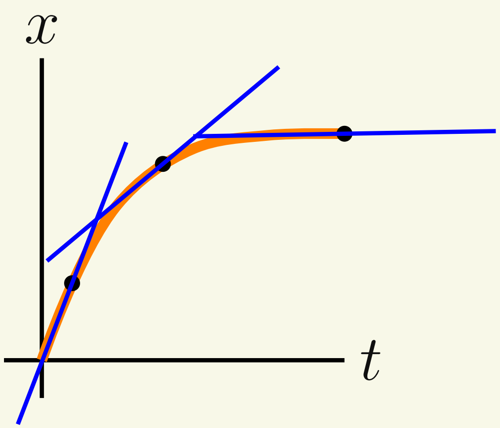
(b)



Speeding Up

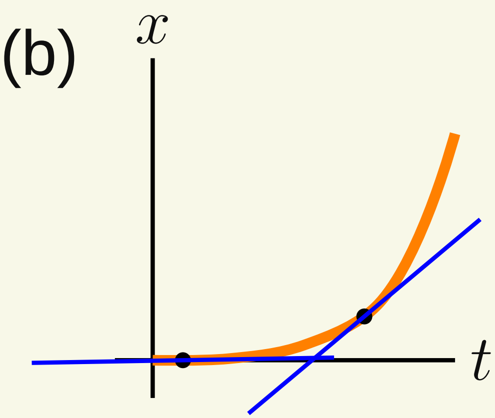
Velocity Followup

(a)



Slowing Down

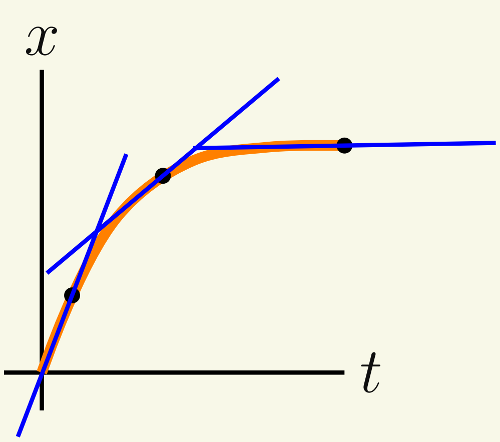
(b)



Speeding Up

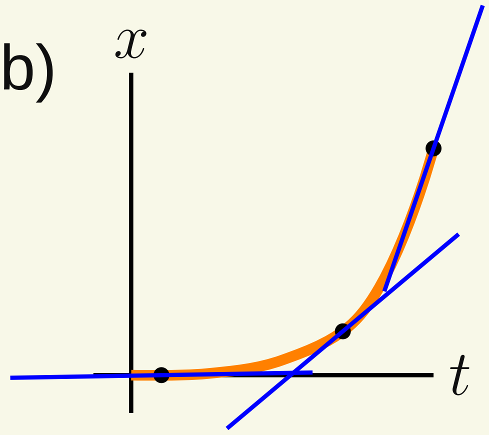
Velocity Followup

(a)



Slowing Down

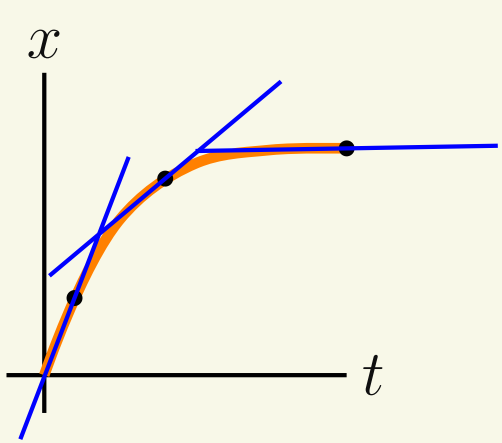
(b)



Speeding Up

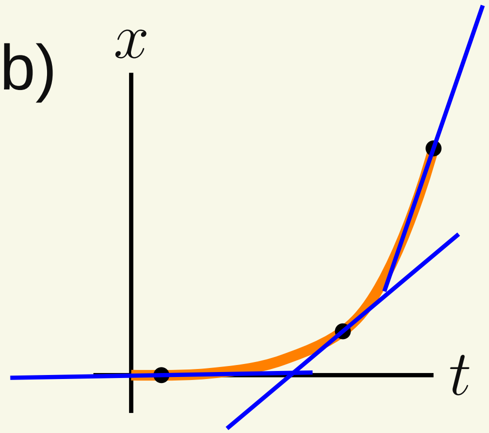
Velocity Followup

(a)



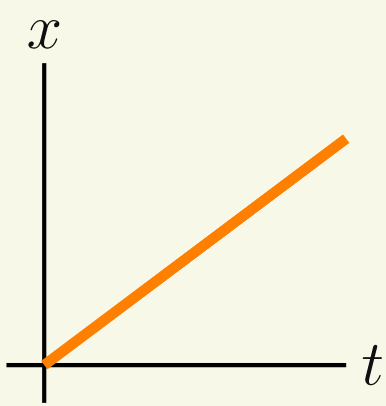
Slowing Down

(b)

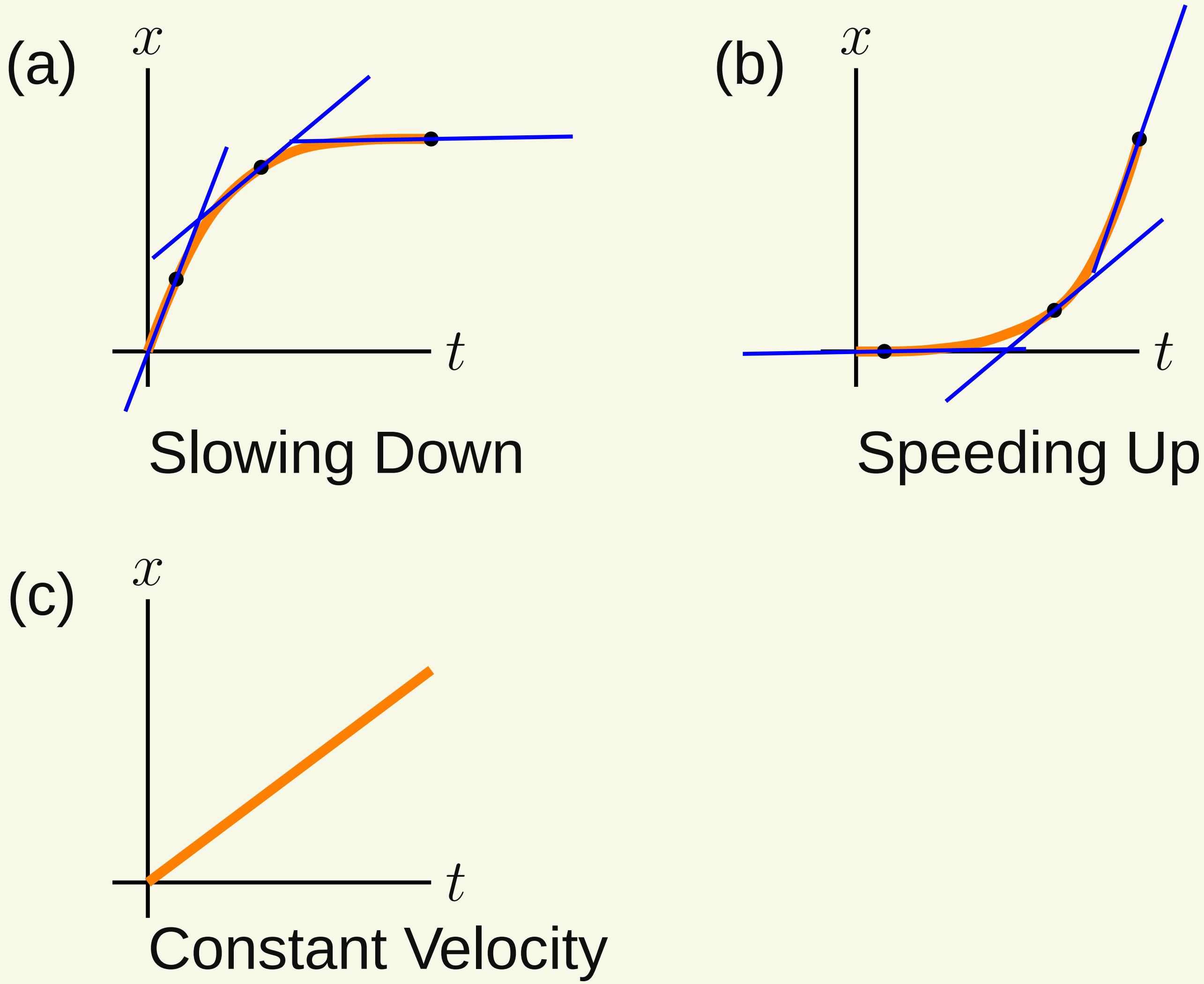


Speeding Up

(c)

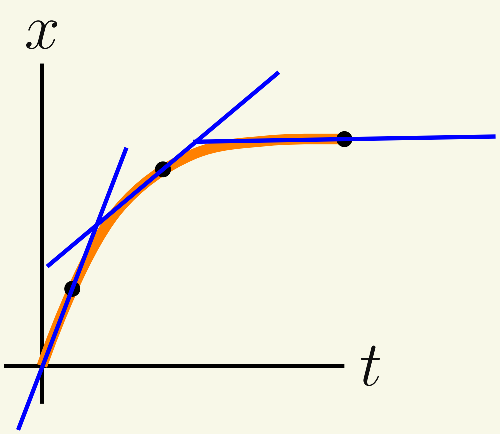


Velocity Followup



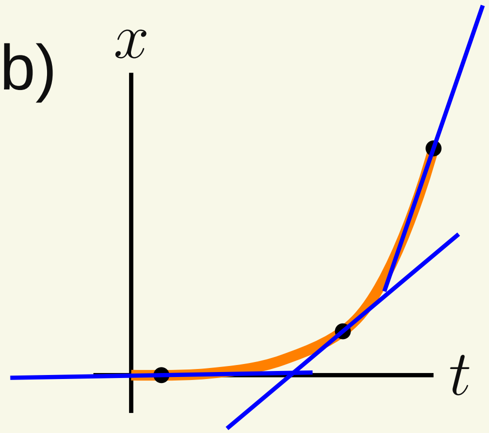
Velocity Followup

(a)



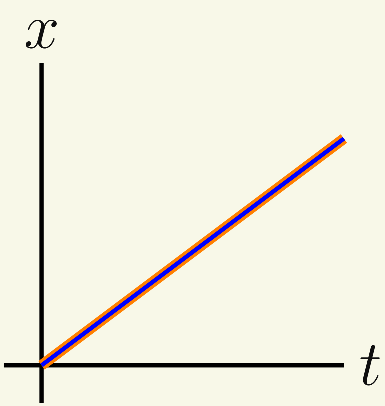
Slowing Down

(b)



Speeding Up

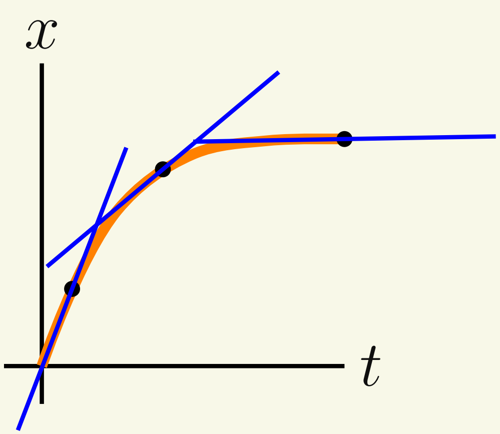
(c)



Constant Velocity

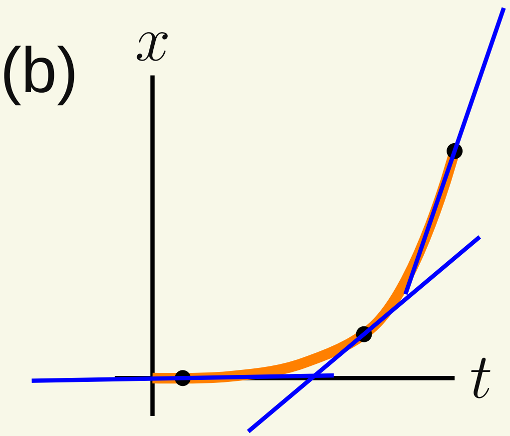
Velocity Followup

(a)



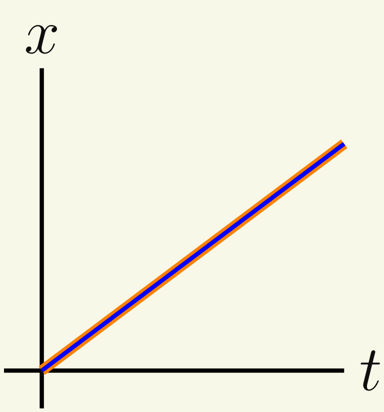
Slowing Down

(b)



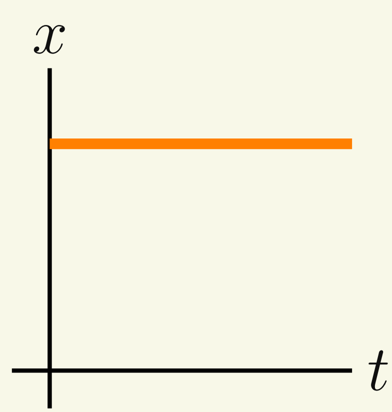
Speeding Up

(c)

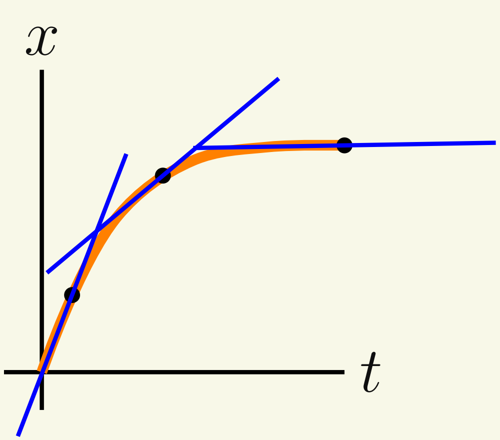


Constant Velocity

(d)

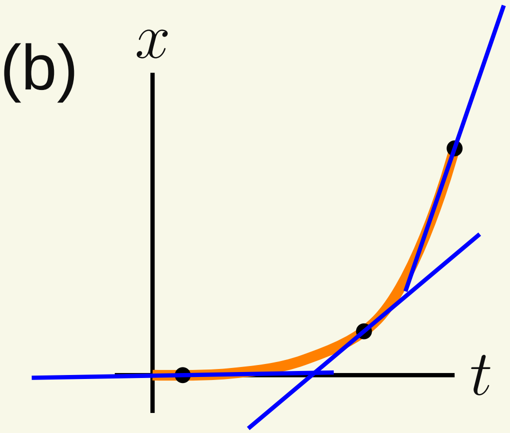


(a)



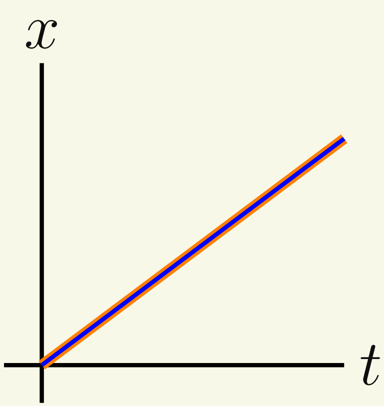
Slowing Down

(b)



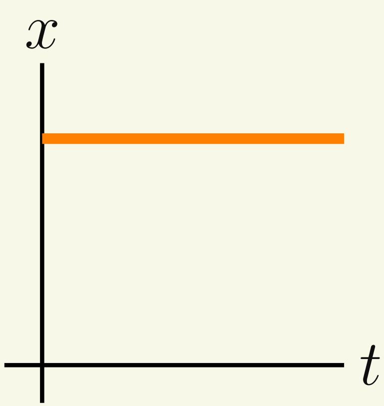
Speeding Up

(c)



Constant Velocity

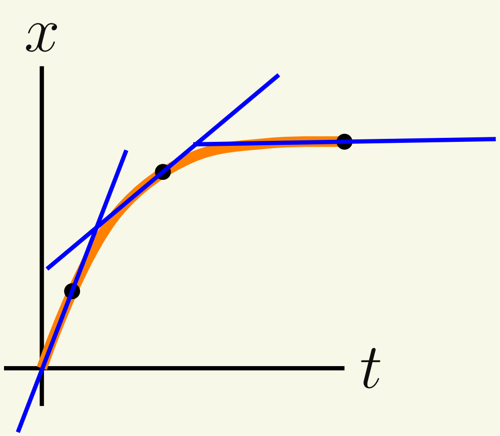
(d)



Zero Velocity

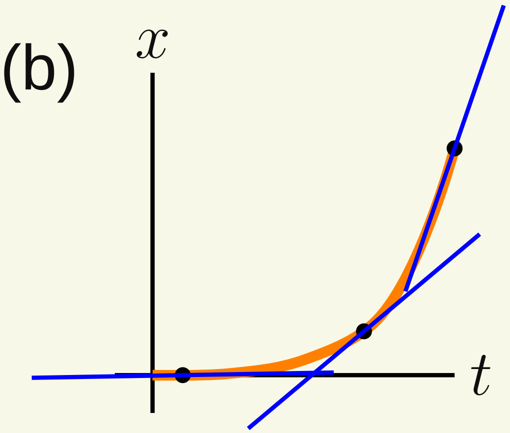
Velocity Followup

(a)



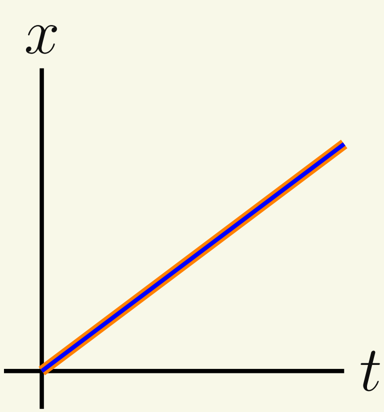
Slowing Down

(b)



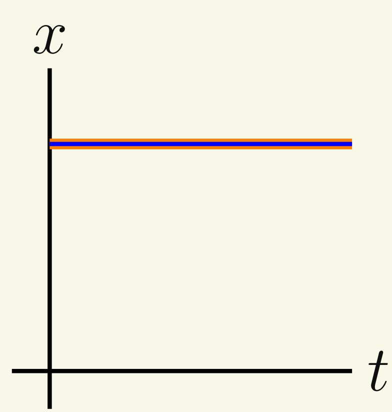
Speeding Up

(c)



Constant Velocity

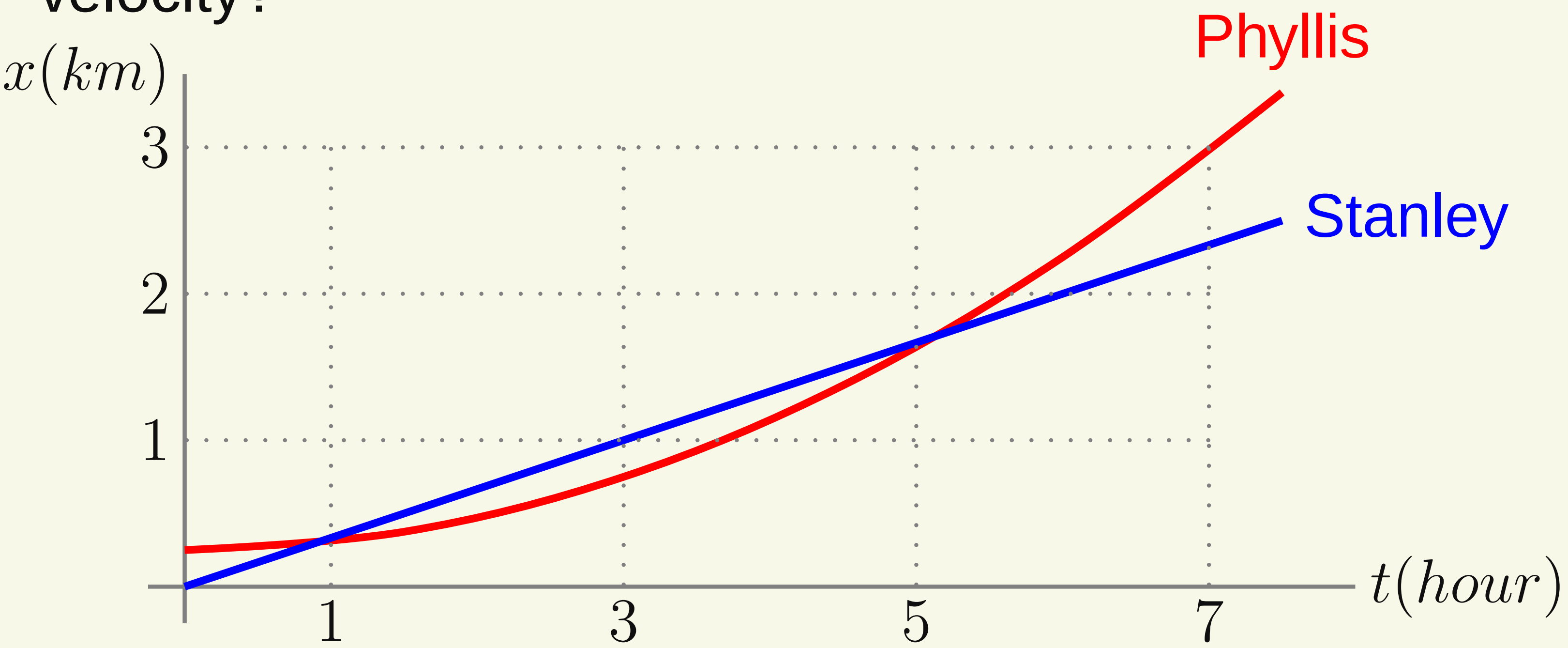
(d)



Zero Velocity

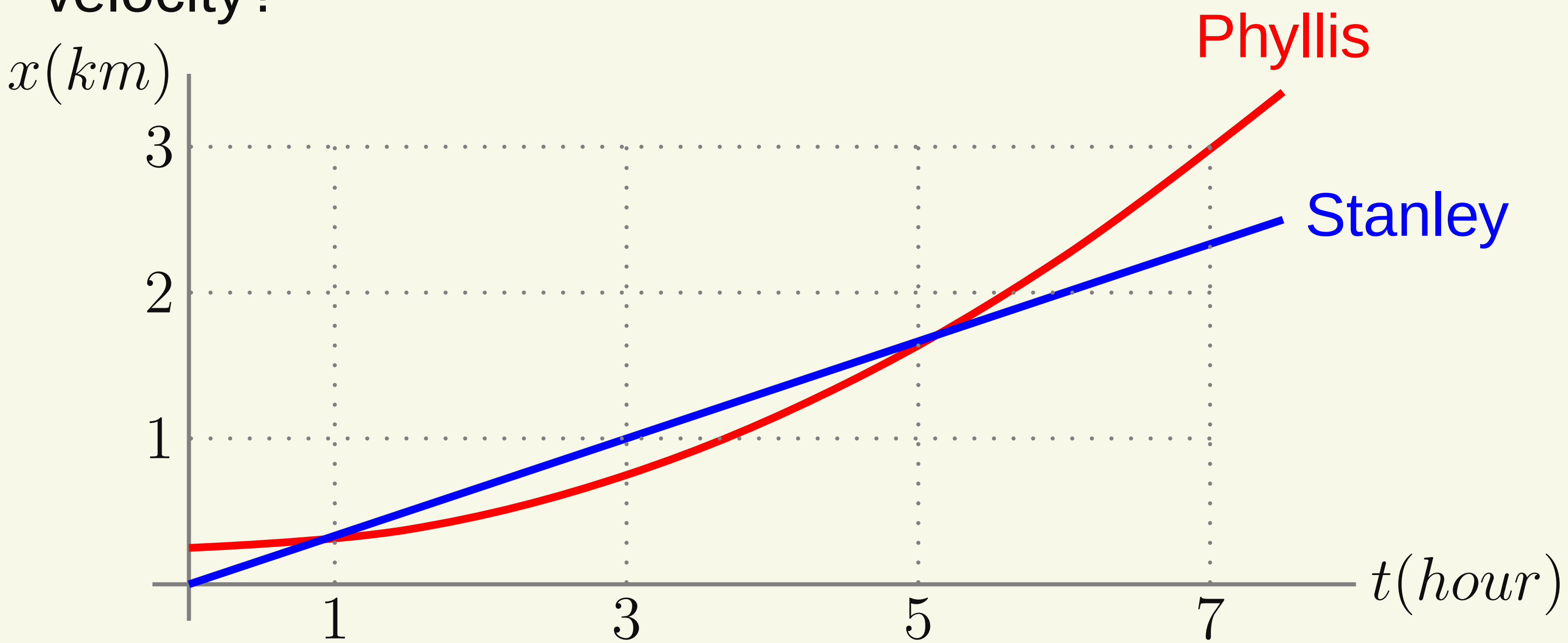
Velocity Exercise II

The position-versus-time graphs for two people, Phyllis and Stanley, are shown below. At what time or times do they have the same velocity?



Velocity Exercise II

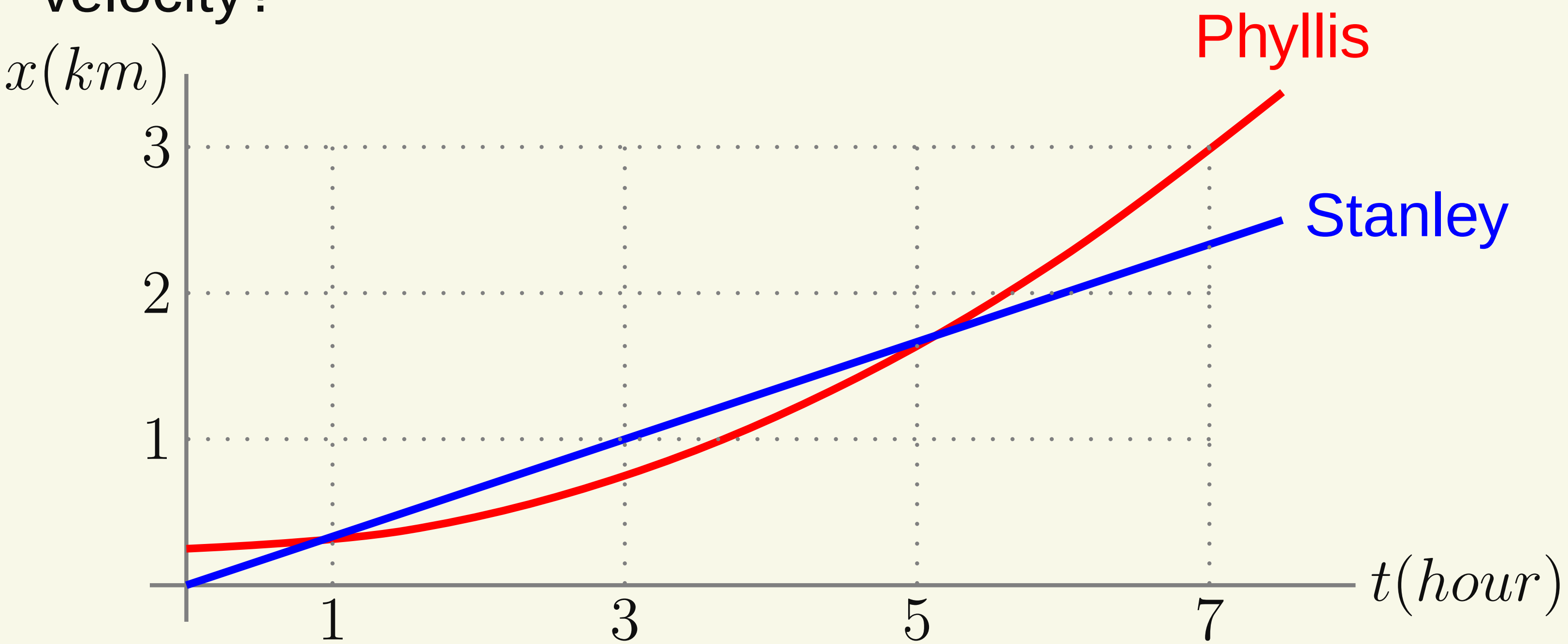
The position-versus-time graphs for two people, Phyllis and Stanley, are shown below. At what time or times do they have the same velocity?



(a) $1\,h$

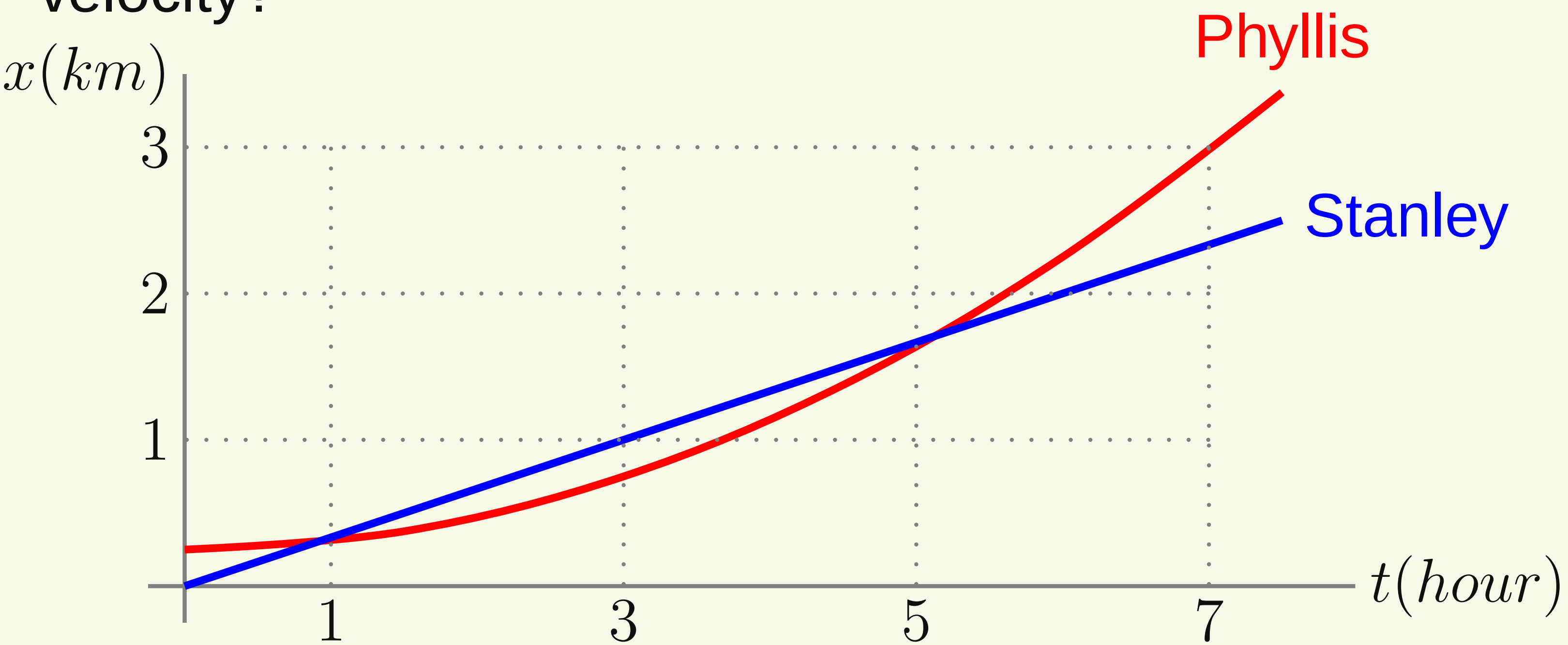
Velocity Exercise II

The position-versus-time graphs for two people, Phyllis and Stanley, are shown below. At what time or times do they have the same velocity?



(a) $1\,h$ (b) $3\,h$

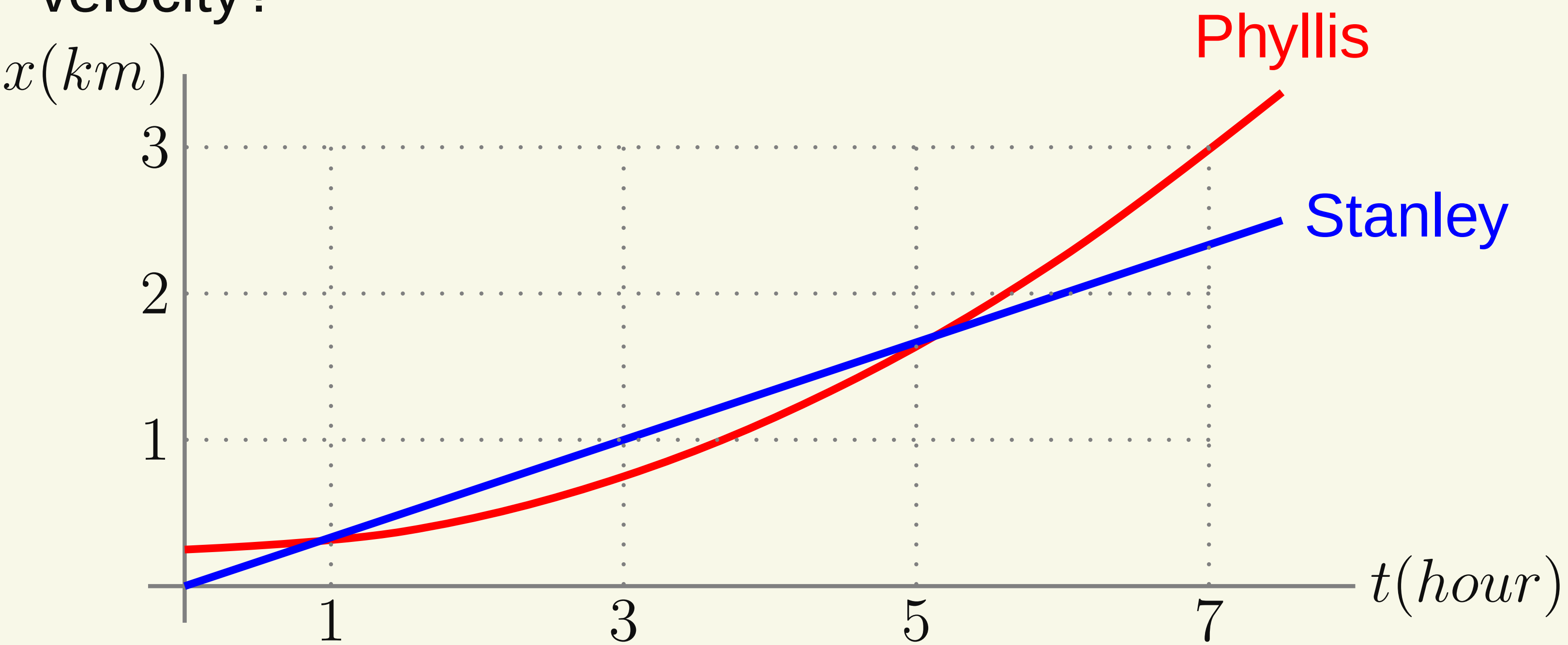
The position-versus-time graphs for two people, Phyllis and Stanley, are shown below. At what time or times do they have the same velocity?



(a) $1\,h$ (b) $3\,h$ (c) $5\,h$

Velocity Exercise II

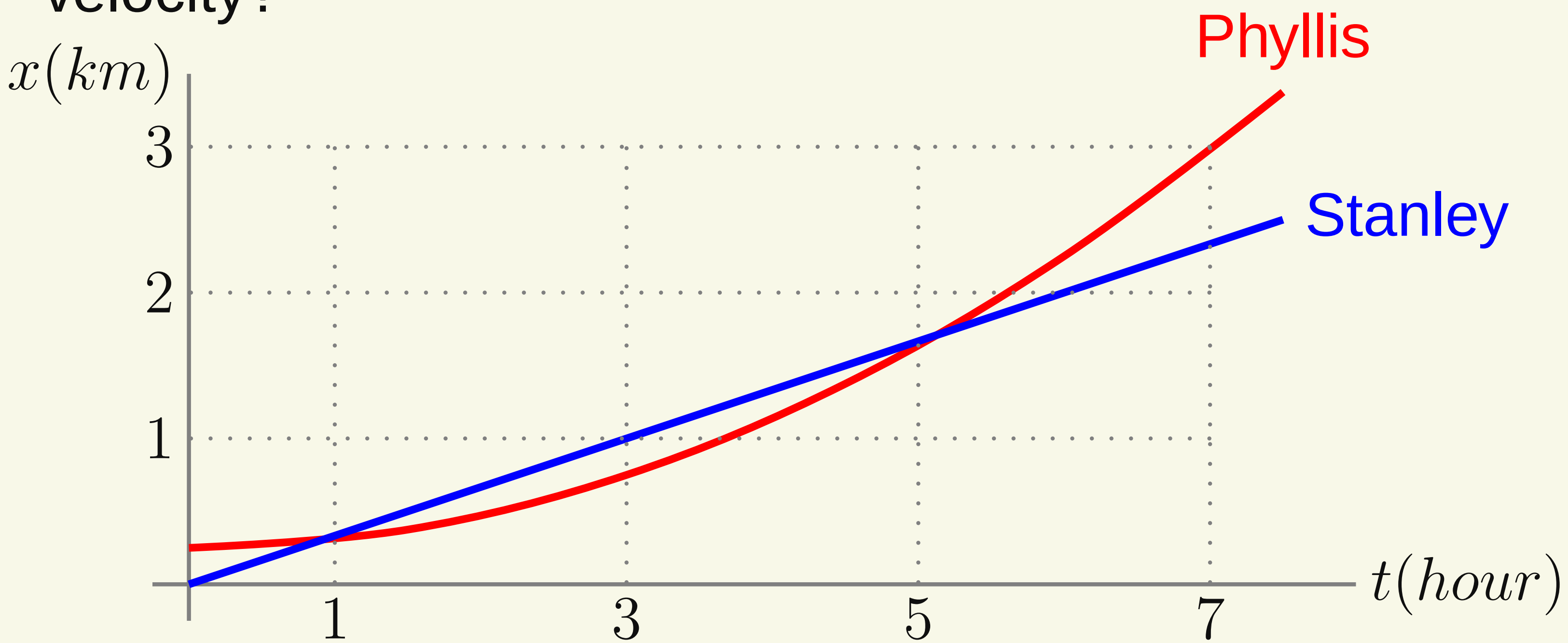
The position-versus-time graphs for two people, Phyllis and Stanley, are shown below. At what time or times do they have the same velocity?



(a) $1\,h$ (b) $3\,h$ (c) $5\,h$ (d) Both $1\,h$ and $5\,h$

Velocity Exercise II

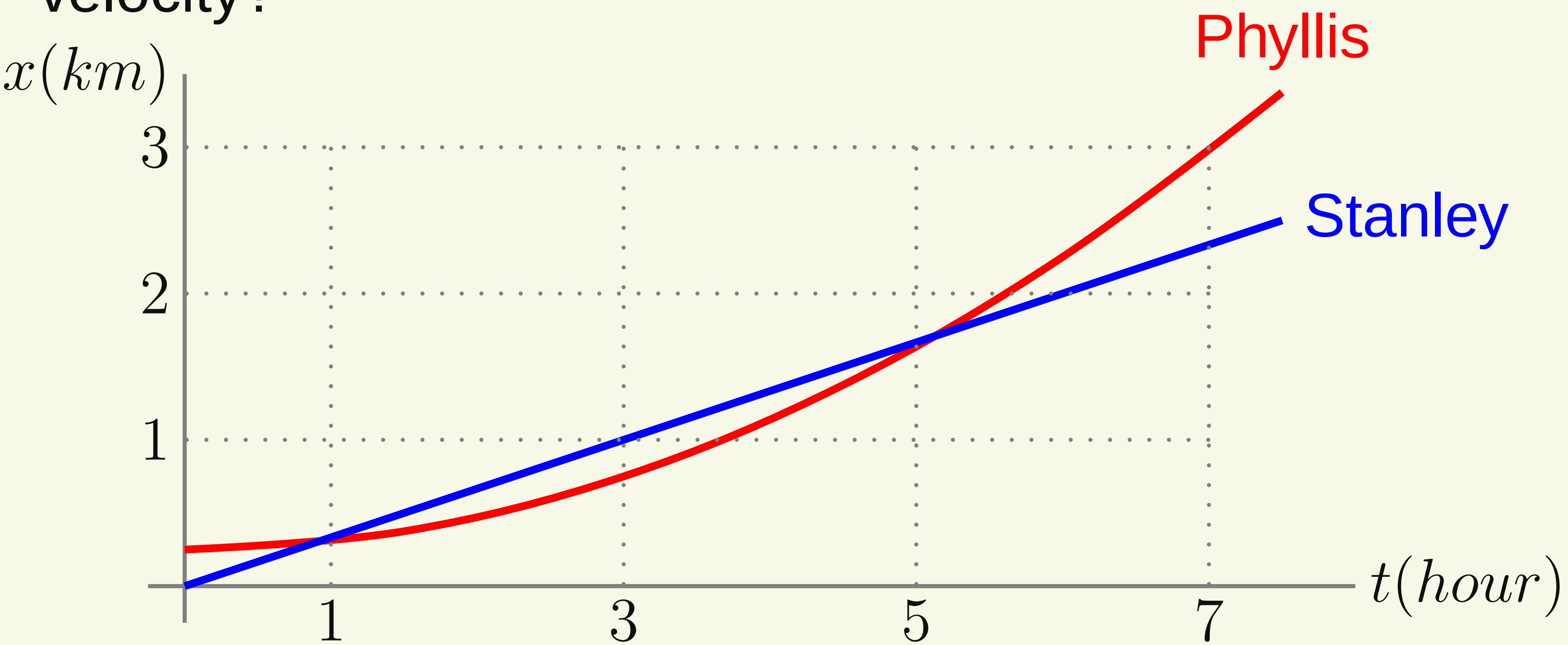
The position-versus-time graphs for two people, Phyllis and Stanley, are shown below. At what time or times do they have the same velocity?



(a) $1\,h$ (b) $3\,h$ (c) $5\,h$ (d) Both $1\,h$ and $5\,h$ (e) $7\,h$

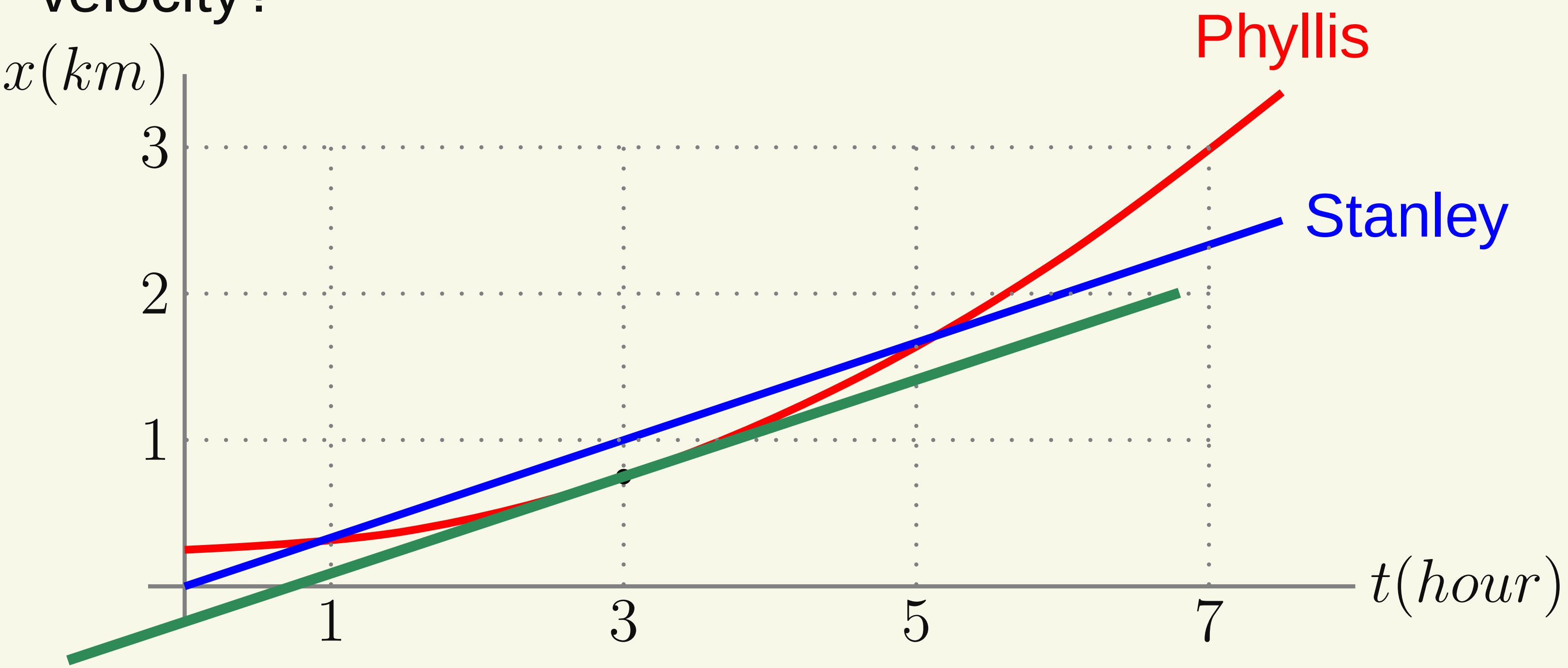
Velocity Exercise II

The position-versus-time graphs for two people, Phyllis and Stanley, are shown below. At what time or times do they have the same velocity?



(a) $1\,h$ $\quad$ $\boxed{\text{(b) } 3\,h}$ $\quad$ (c) $5\,h$ $\quad$ (d) Both $1\,h$ and $5\,h$ $\quad$ (e) $7\,h$

The position-versus-time graphs for two people, Phyllis and Stanley, are shown below. At what time or times do they have the same velocity?



(a) $1\,h$ $\boxed{\text{(b) } 3\,h}$ (c) $5\,h$ (d) Both $1\,h$ and $5\,h$ (e) $7\,h$

Acceleration

Acceleration, a_x - rate at which *velocity* changes.

Acceleration

Acceleration, a_x - rate at which *velocity* changes.

Since we are only going to do constant acceleration problems:

$$a_x = \frac{\Delta v_x}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$$

Acceleration

Acceleration, a_x - rate at which *velocity* changes.

Since we are only going to do constant acceleration problems:

$$a_x = \frac{\Delta v_x}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$$

Unit: $\frac{m/s}{s}$

Acceleration

Acceleration, a_x - rate at which *velocity* changes.

Since we are only going to do constant acceleration problems:

$$a_x = \frac{\Delta v_x}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$$

Unit: $\frac{m/s}{s} = m/s^2$

Acceleration Exercise

A rabbit accelerates from rest to $4\,m/s$ in $1\,s$. For a turtle to have a larger acceleration than the rabbit, he would need to go from rest to $2\,m/s$ in a time that is:

Acceleration Exercise

A rabbit accelerates from rest to $4\,m/s$ in $1\,s$. For a turtle to have a larger acceleration than the rabbit, he would need to go from rest to $2\,m/s$ in a time that is:

(a) Larger than $2\,s$

Acceleration Exercise

A rabbit accelerates from rest to $4\,m/s$ in $1\,s$. For a turtle to have a larger acceleration than the rabbit, he would need to go from rest to $2\,m/s$ in a time that is:

(a) Larger than $2\,s$

(b) Between $1\,s$ and $2\,s$

Acceleration Exercise

A rabbit accelerates from rest to $4\,m/s$ in $1\,s$. For a turtle to have a larger acceleration than the rabbit, he would need to go from rest to $2\,m/s$ in a time that is:

(a) Larger than $2\,s$

(b) Between $1\,s$ and $2\,s$

(c) Between $0.5\,s$ and $1\,s$

Acceleration Exercise

A rabbit accelerates from rest to $4\,m/s$ in $1\,s$. For a turtle to have a larger acceleration than the rabbit, he would need to go from rest to $2\,m/s$ in a time that is:

(a) Larger than $2\,s$

(b) Between $1\,s$ and $2\,s$

(c) Between $0.5\,s$ and $1\,s$

(d) Smaller than $0.5\,s$

Acceleration Exercise

A rabbit accelerates from rest to $4\,m/s$ in $1\,s$. For a turtle to have a larger acceleration than the rabbit, he would need to go from rest to $2\,m/s$ in a time that is:

(a) Larger than $2\,s$

(b) Between $1\,s$ and $2\,s$

(c) Between $0.5\,s$ and $1\,s$

(d) Smaller than $0.5\,s$

(e) It is physically impossible for a turtle to have a larger acceleration than a rabbit.

Acceleration Exercise

A rabbit accelerates from rest to $4\,m/s$ in $1\,s$. For a turtle to have a larger acceleration than the rabbit, he would need to go from rest to $2\,m/s$ in a time that is:

(a) Larger than $2\,s$

(b) Between $1\,s$ and $2\,s$

(c) Between $0.5\,s$ and $1\,s$

(d) Smaller than $0.5\,s$

(e) It is physically impossible for a turtle to have a larger acceleration than a rabbit.

Acceleration Exercise

A rabbit accelerates from rest to $4\,m/s$ in $1\,s$. For a turtle to have a larger acceleration than the rabbit, he would need to go from rest to $2\,m/s$ in a time that is:

For the rabbit:

$$a_r = \frac{4\,m/s}{1\,s} = 4\,m/s^2$$

(d) Smaller than $0.5\,s$

Acceleration Exercise

A rabbit accelerates from rest to $4\,m/s$ in $1\,s$. For a turtle to have a larger acceleration than the rabbit, he would need to go from rest to $2\,m/s$ in a time that is:

For the rabbit:

$$a_r = \frac{4\,m/s}{1\,s} = 4\,m/s^2$$

For the turtle: $a_t = \dfrac{2\,m/s}{\Delta t_t}$

$\boxed{\text{(d) Smaller than } 0.5\,s}$

Acceleration Exercise

A rabbit accelerates from rest to $4\,m/s$ in $1\,s$. For a turtle to have a larger acceleration than the rabbit, he would need to go from rest to $2\,m/s$ in a time that is:

For the rabbit:

$$a_r = \frac{4\,m/s}{1\,s} = 4\,m/s^2$$

For the turtle: $a_t = \dfrac{2\,m/s}{\Delta t_t}$

$\boxed{\text{(d) Smaller than } 0.5\,s}$

For $\Delta t_t = 0.5\,s$: $a_t = \dfrac{2\,m/s}{0.5\,s} = 4\,m/s^2$

Acceleration Exercise

A rabbit accelerates from rest to $4\,m/s$ in $1\,s$. For a turtle to have a larger acceleration than the rabbit, he would need to go from rest to $2\,m/s$ in a time that is:

$\boxed{\text{(d) Smaller than } 0.5\,s}$

For the rabbit:

$$a_r = \frac{4\,m/s}{1\,s} = 4\,m/s^2$$

For the turtle: $a_t = \dfrac{2\,m/s}{\Delta t_t}$

For $\Delta t_t = 0.5\,s$: $a_t = \dfrac{2\,m/s}{0.5\,s} = 4\,m/s^2$

Dividing by a smaller number gives a larger result.

Acceleration II

As with velocity, instantaneous acceleration, a, is a slope.

Acceleration II

As with velocity, instantaneous acceleration, a, is a slope.

$$a_x = \frac{\Delta v_x}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$$

Acceleration II

As with velocity, instantaneous acceleration, a, is a slope.

$$a_x = \frac{\Delta v_x}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$$

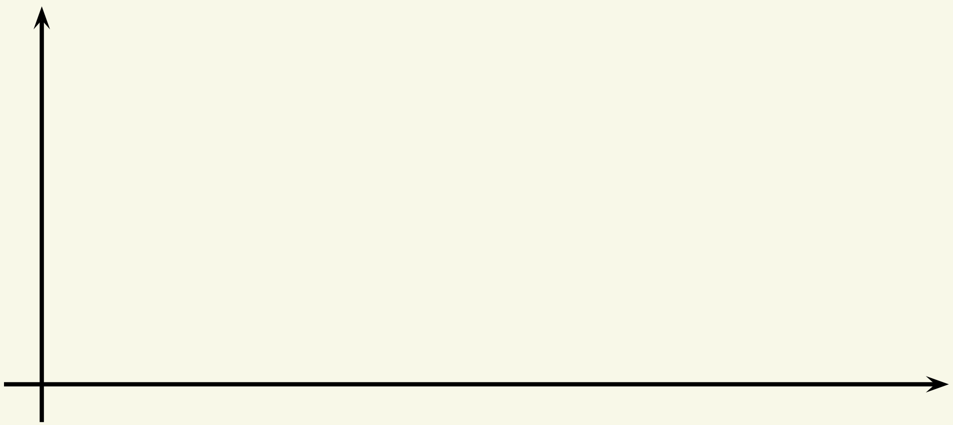
Acceleration is the slope of the velocity-versus-time graph.

Acceleration II

As with velocity, instantaneous acceleration, a, is a slope.

$$a_x = \frac{\Delta v_x}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$$

Acceleration is the slope of the velocity-versus-time graph.

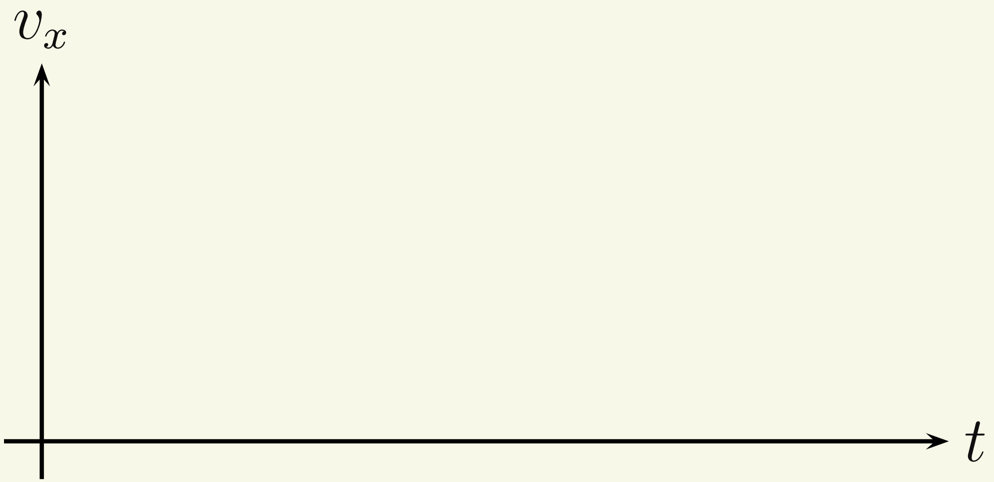


Acceleration II

As with velocity, instantaneous acceleration, a, is a slope.

$$a_x = \frac{\Delta v_x}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$$

Acceleration is the slope of the velocity-versus-time graph.

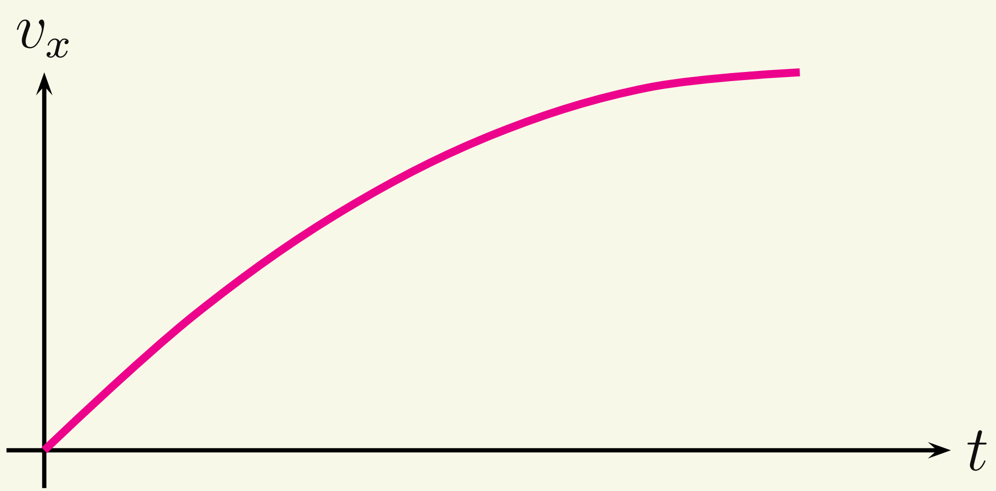


Acceleration II

As with velocity, instantaneous acceleration, a, is a slope.

$$a_x = \frac{\Delta v_x}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$$

Acceleration is the slope of the velocity-versus-time graph.

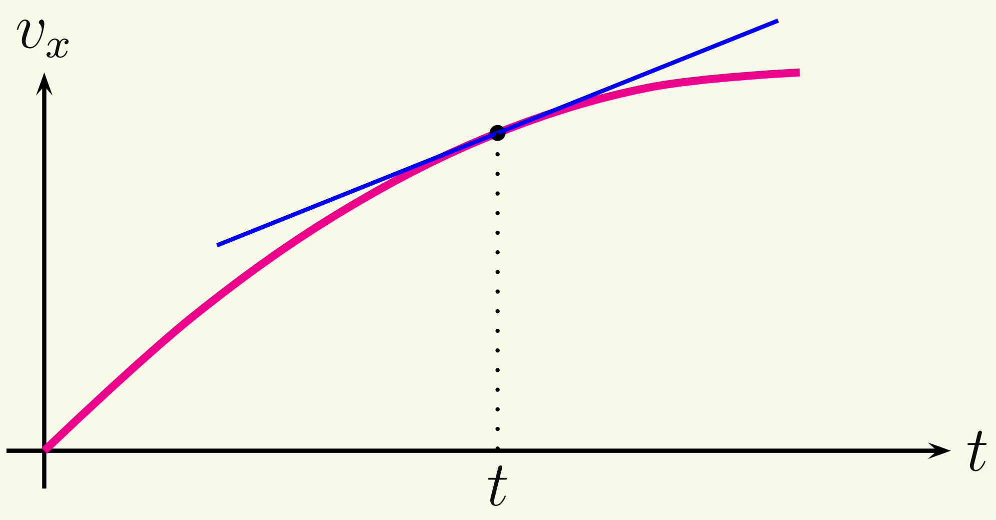


Acceleration II

As with velocity, instantaneous acceleration, a, is a slope.

$$a_x = \frac{\Delta v_x}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$$

Acceleration is the slope of the velocity-versus-time graph.

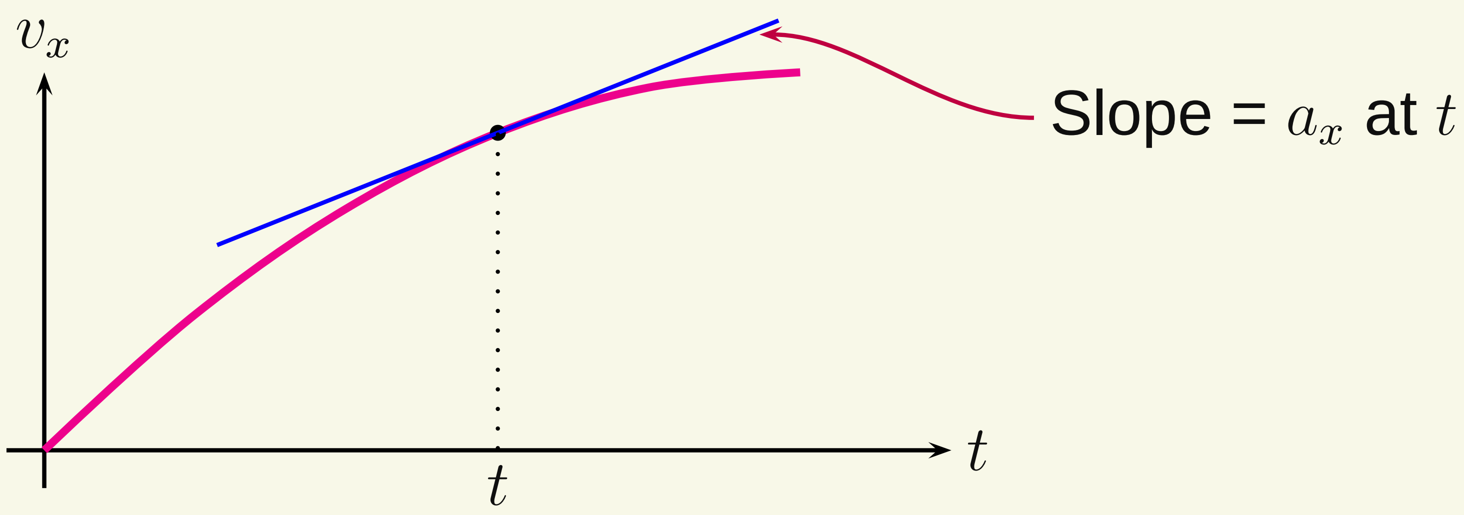


Acceleration II

As with velocity, instantaneous acceleration, a, is a slope.

$$a_x = \frac{\Delta v_x}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$$

Acceleration is the slope of the velocity-versus-time graph.



Acceleration versus Deceleration

The direction (and therefore) sign of acceleration is more complicated than position's or velocity's

Acceleration versus Deceleration

The direction (and therefore) sign of acceleration is more complicated than position's or velocity's

You *cannot* say that positive a_x means speeding up and negative a_x means slowing down.

Acceleration versus Deceleration

The direction (and therefore) sign of acceleration is more complicated than position's or velocity's

You *cannot* say that positive a_x means speeding up and negative a_x means slowing down.

$\boxed{a_x \text{ is in the same direction of } \Delta v}$

Acceleration versus Deceleration

The direction (and therefore) sign of acceleration is more complicated than position's or velocity's

You *cannot* say that positive a_x means speeding up and negative a_x means slowing down.

$\boxed{a_x \text{ is in the same direction of } \Delta v}$

Speeding Up

Acceleration versus Deceleration

The direction (and therefore) sign of acceleration is more complicated than position's or velocity's

You *cannot* say that positive a_x means speeding up and negative a_x means slowing down.

a_x is in the same direction of Δv

Speeding Up

Acceleration versus Deceleration

The direction (and therefore) sign of acceleration is more complicated than position's or velocity's

You *cannot* say that positive a_x means speeding up and negative a_x means slowing down.

$\boxed{a_x \text{ is in the same direction of } \Delta v}$

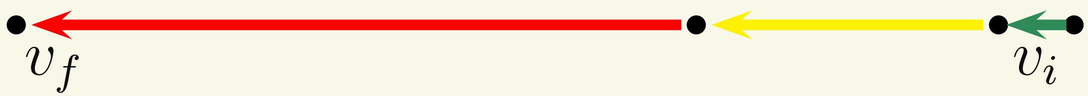
Speeding Up

Acceleration versus Deceleration

The direction (and therefore) sign of acceleration is more complicated than position's or velocity's

You *cannot* say that positive a_x means speeding up and negative a_x means slowing down.

$\boxed{a_x \text{ is in the same direction of } \Delta v}$



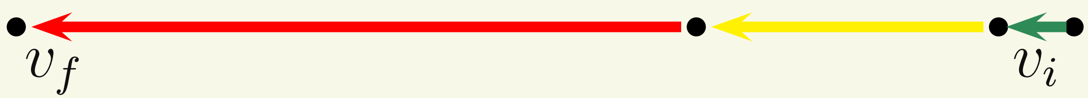
Speeding Up

Acceleration versus Deceleration

The direction (and therefore) sign of acceleration is more complicated than position's or velocity's

You *cannot* say that positive a_x means speeding up and negative a_x means slowing down.

$\boxed{a_x \text{ is in the same direction of } \Delta v}$



Speeding Up

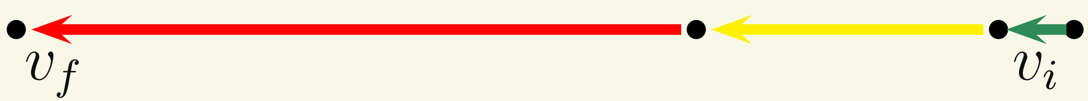
Have to redraw v's starting at the same place

Acceleration versus Deceleration

The direction (and therefore) sign of acceleration is more complicated than position's or velocity's

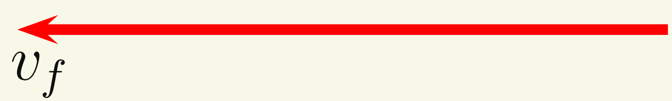
You *cannot* say that positive a_x means speeding up and negative a_x means slowing down.

$\boxed{a_x \text{ is in the same direction of } \Delta v}$



Speeding Up

Have to redraw v's starting at the same place

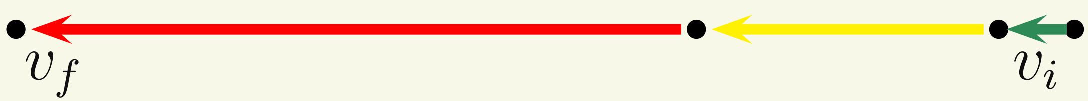


Acceleration versus Deceleration

The direction (and therefore) sign of acceleration is more complicated than position's or velocity's

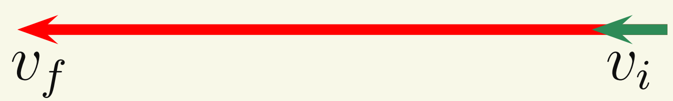
You *cannot* say that positive a_x means speeding up and negative a_x means slowing down.

$\boxed{a_x \text{ is in the same direction of } \Delta v}$



Speeding Up

Have to redraw v's starting at the same place

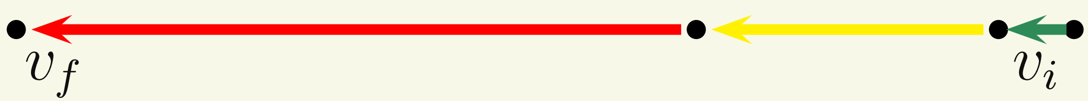


Acceleration versus Deceleration

The direction (and therefore) sign of acceleration is more complicated than position's or velocity's

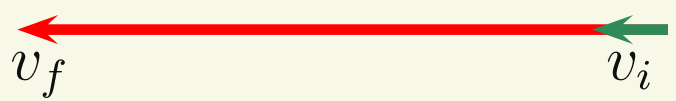
You *cannot* say that positive a_x means speeding up and negative a_x means slowing down.

a_x is in the same direction of Δv



Speeding Up

Have to redraw v's starting at the same place



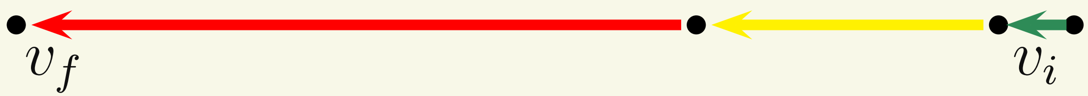
Δv points *from* the end of v_i *to* the end of v_f

Acceleration versus Deceleration

The direction (and therefore) sign of acceleration is more complicated than position's or velocity's

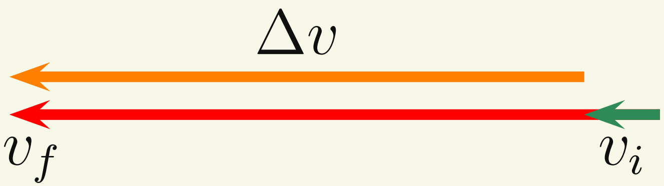
You *cannot* say that positive a_x means speeding up and negative a_x means slowing down.

$\boxed{a_x \text{ is in the same direction of } \Delta v}$



Speeding Up

Have to redraw v's starting at the same place



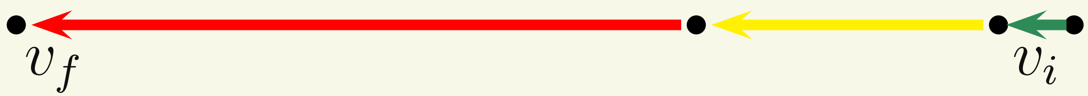
Δv points *from* the end of v_i *to* the end of v_f

Acceleration versus Deceleration

The direction (and therefore) sign of acceleration is more complicated than position's or velocity's

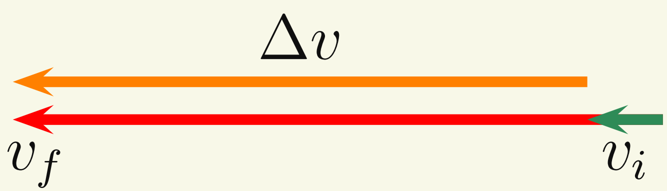
You *cannot* say that positive a_x means speeding up and negative a_x means slowing down.

$\boxed{a_x \text{ is in the same direction of } \Delta v}$



Speeding Up

Have to redraw v's starting at the same place



Δv points *from* the end of v_i *to* the end of v_f

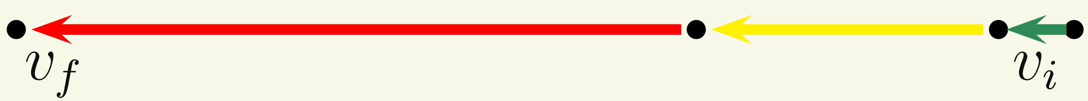
Δv to left $\Rightarrow$ a_x to left $\Rightarrow$ a_x is negative.

Acceleration versus Deceleration

The direction (and therefore) sign of acceleration is more complicated than position's or velocity's

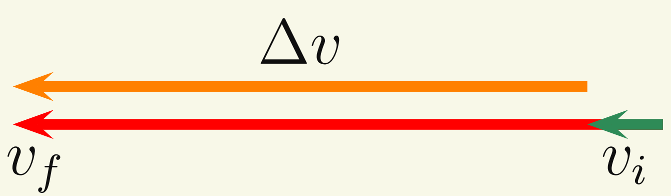
You *cannot* say that positive a_x means speeding up and negative a_x means slowing down.

$\boxed{a_x \text{ is in the same direction of } \Delta v}$



Speeding Up

Have to redraw v's starting at the same place



Δv points *from* the end of v_i *to* the end of v_f

Δv to left $\Rightarrow a_x$ to left $\Rightarrow a_x$ is negative.

If you prefer: The velocity got *more* negative with time.

Acceleration versus Deceleration II

In Summary:

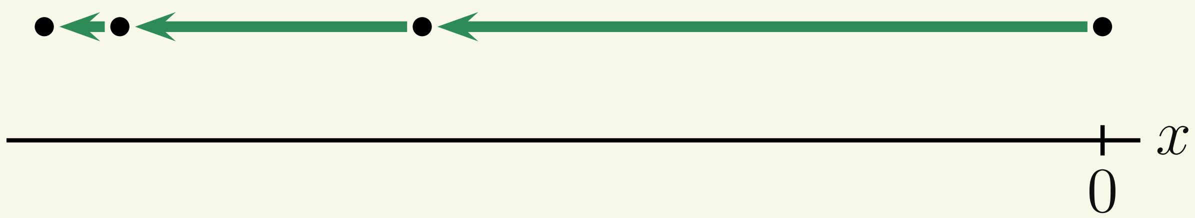
When a_x and v_x have the same sign, speed increases.
When a_x and v_x have the opposite sign, speed decreases.

Acceleration Exercise

For the following motion diagram and coordinate system, which of the following are correct signs for its kinematical quantities?

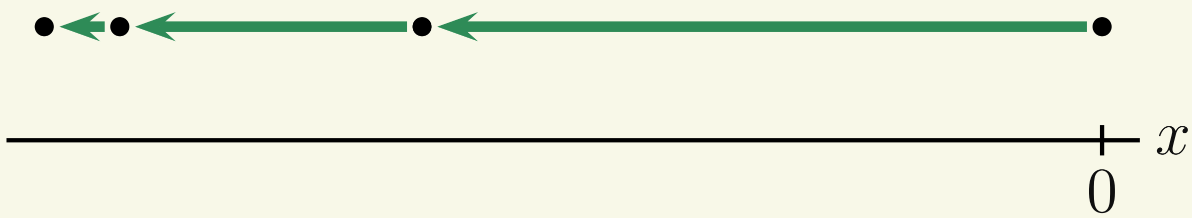
Acceleration Exercise

For the following motion diagram and coordinate system, which of the following are correct signs for its kinematical quantities?



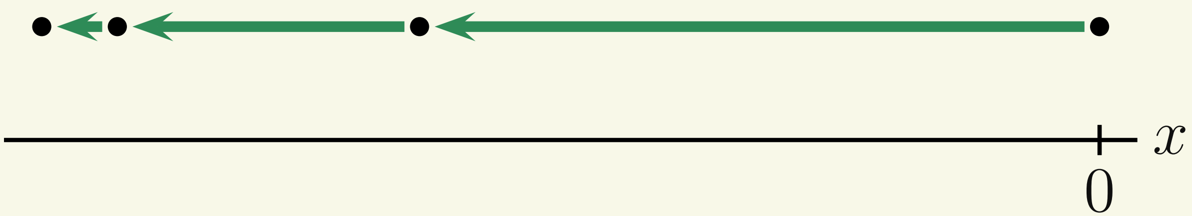
Acceleration Exercise

For the following motion diagram and coordinate system, which of the following are correct signs for its kinematical quantities?



	x	v_x	a_x

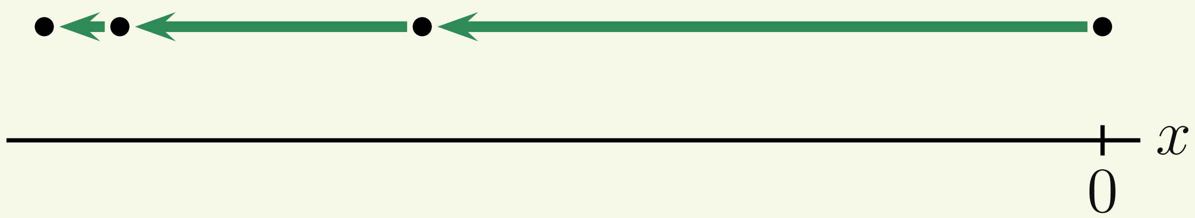
For the following motion diagram and coordinate system, which of the following are correct signs for its kinematical quantities?



	x	v_x	a_x
(a)	$-$	$+$	$+$

Acceleration Exercise

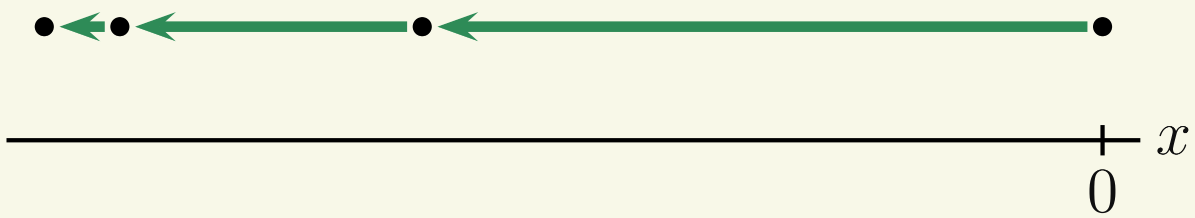
For the following motion diagram and coordinate system, which of the following are correct signs for its kinematical quantities?



	x	v_x	a_x
(a)	$-$	$+$	$+$
(b)	$-$	$+$	$-$

Acceleration Exercise

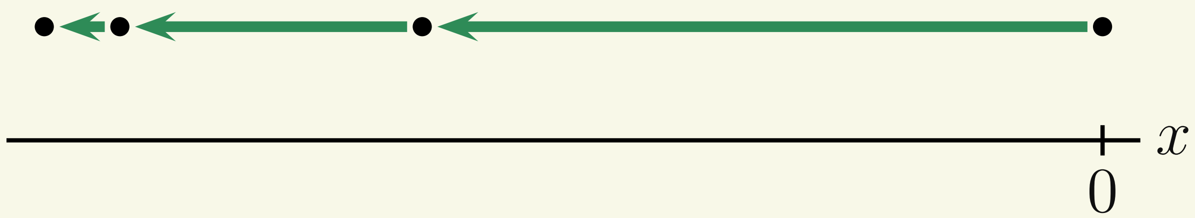
For the following motion diagram and coordinate system, which of the following are correct signs for its kinematical quantities?



	x	v_x	a_x
(a)	$-$	$+$	$+$
(b)	$-$	$+$	$-$
(c)	$-$	$-$	$+$

Acceleration Exercise

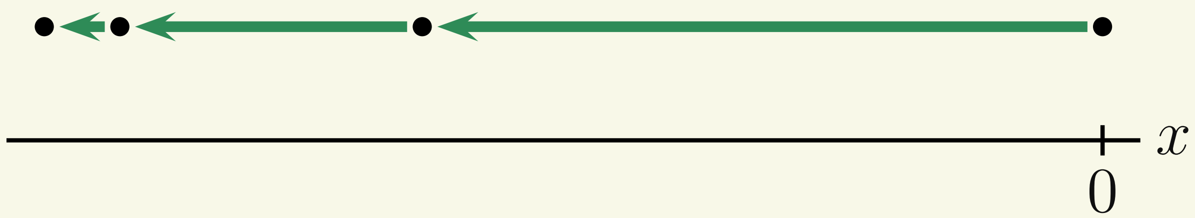
For the following motion diagram and coordinate system, which of the following are correct signs for its kinematical quantities?



	x	v_x	a_x
(a)	$-$	$+$	$+$
(b)	$-$	$+$	$-$
(c)	$-$	$-$	$+$
(d)	$-$	$-$	$-$

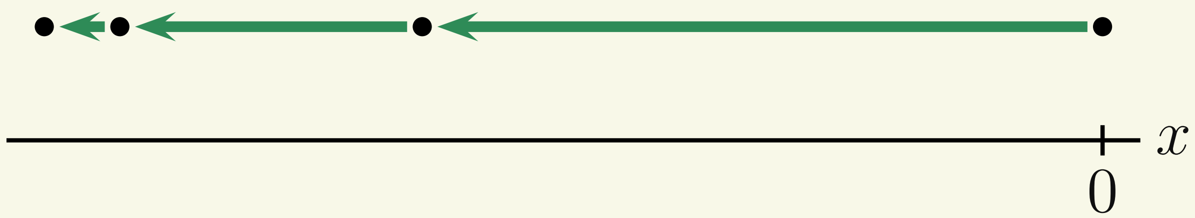
Acceleration Exercise

For the following motion diagram and coordinate system, which of the following are correct signs for its kinematical quantities?



	x	v_x	a_x
(a)	$-$	$+$	$+$
(b)	$-$	$+$	$-$
(c)	$-$	$-$	$+$
(d)	$-$	$-$	$-$
(e)	$+$	$-$	$+$

For the following motion diagram and coordinate system, which of the following are correct signs for its kinematical quantities?



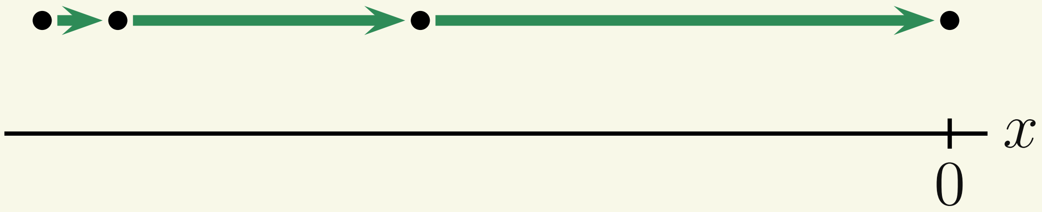
	x	v_x	a_x
(a)	$-$	$+$	$+$
(b)	$-$	$+$	$-$
$\boxed{\text{(c)}}$	$-$	$-$	$+$
(d)	$-$	$-$	$-$
(e)	$+$	$-$	$+$

Acceleration Followup

	x	v_x	a_x
(a)	$-$	$+$	$+$

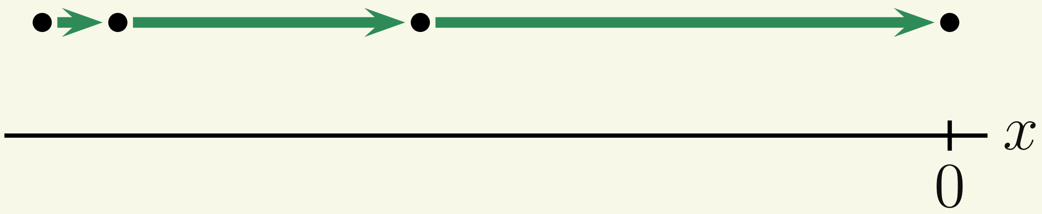
Acceleration Followup

	x	v_x	a_x
(a)	$-$	$+$	$+$



Acceleration Followup

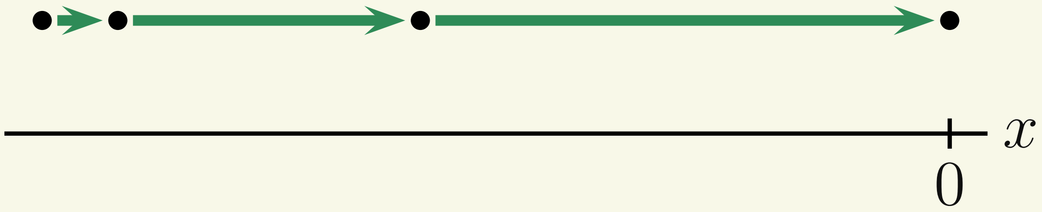
	x	v_x	a_x
(a)	$-$	$+$	$+$



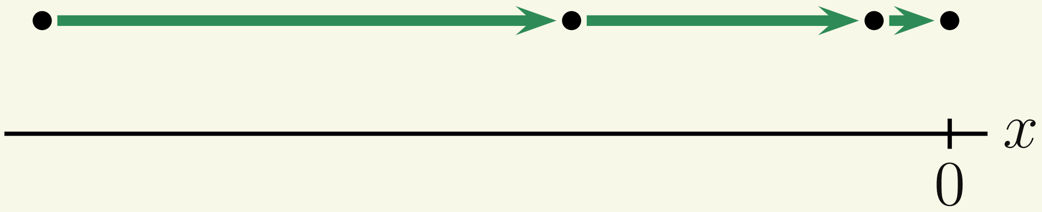
	x	v_x	a_x
(b)	$-$	$+$	$-$

Acceleration Followup

	x	v_x	a_x
(a)	$-$	$+$	$+$

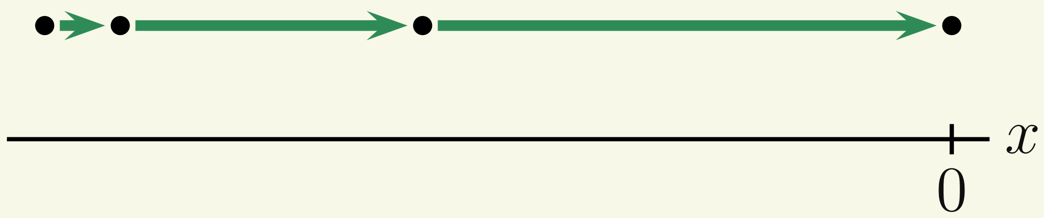


	x	v_x	a_x
(b)	$-$	$+$	$-$

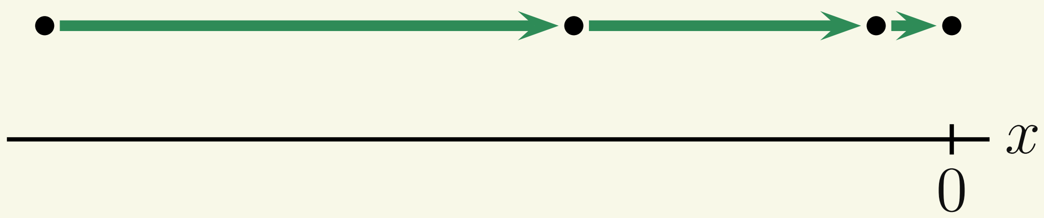


Acceleration Followup

	x	v_x	a_x
(a)	$-$	$+$	$+$



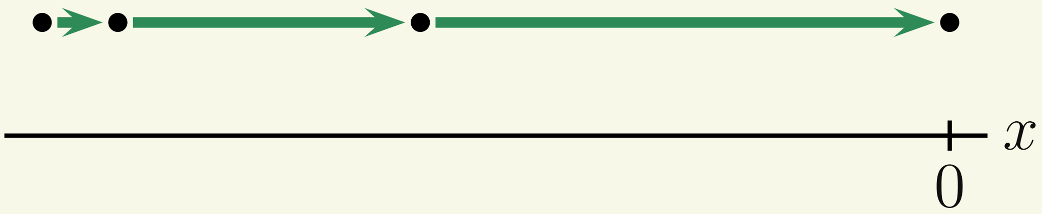
	x	v_x	a_x
(b)	$-$	$+$	$-$



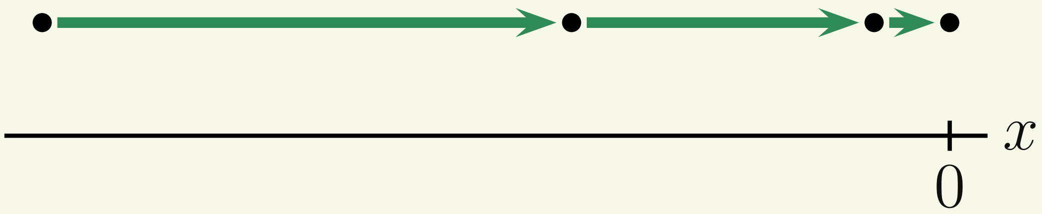
	x	v_x	a_x
(d)	$-$	$-$	$-$

Acceleration Followup

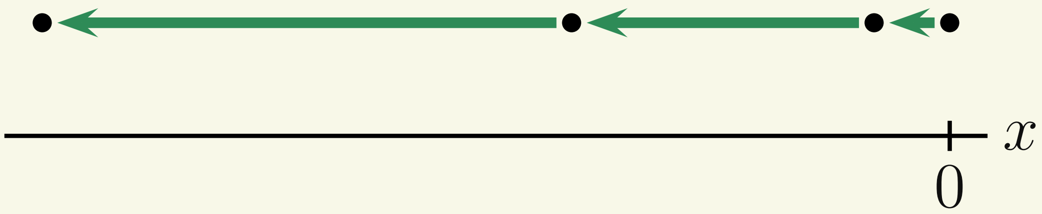
	x	v_x	a_x
(a)	$-$	$+$	$+$



	x	v_x	a_x
(b)	$-$	$+$	$-$

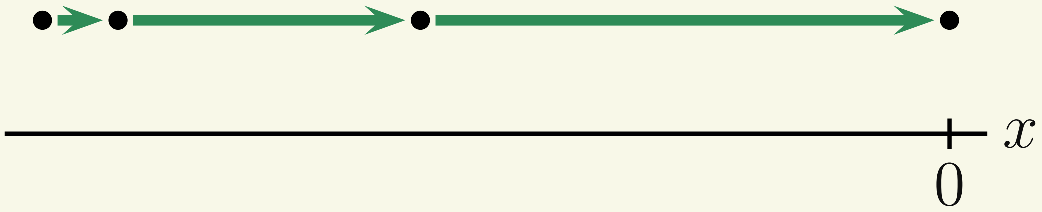


	x	v_x	a_x
(d)	$-$	$-$	$-$

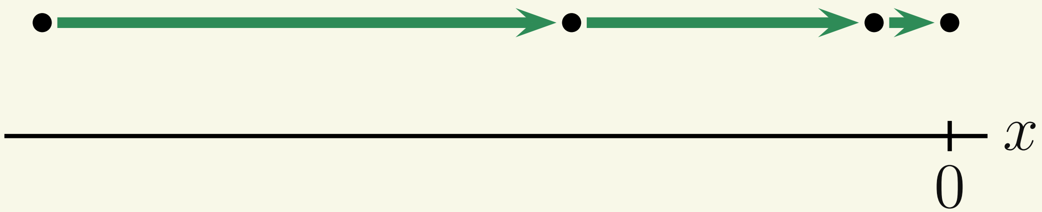


Acceleration Followup

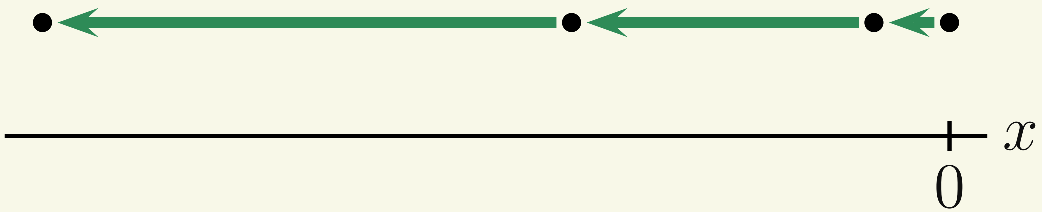
	x	v_x	a_x
(a)	$-$	$+$	$+$



	x	v_x	a_x
(b)	$-$	$+$	$-$



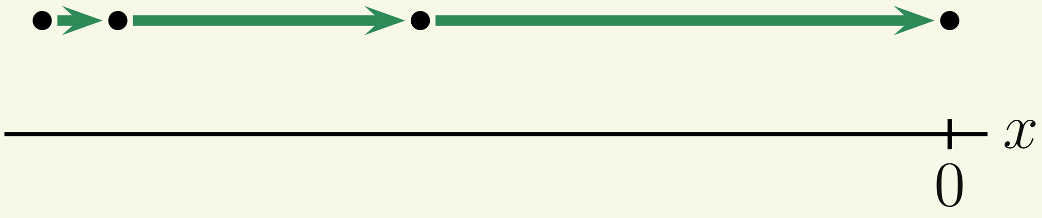
	x	v_x	a_x
(d)	$-$	$-$	$-$



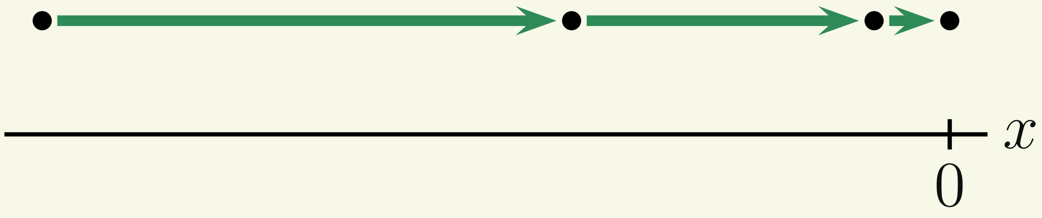
	x	v_x	a_x
(e)	$+$	$-$	$+$

Acceleration Followup

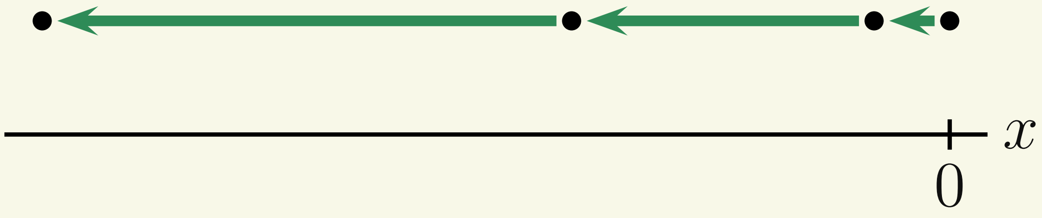
	x	v_x	a_x
(a)	$-$	$+$	$+$



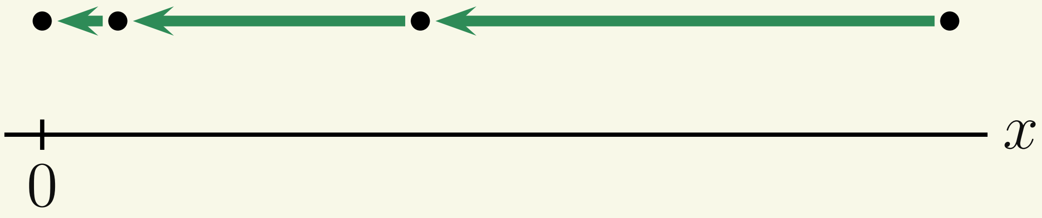
	x	v_x	a_x
(b)	$-$	$+$	$-$



	x	v_x	a_x
(d)	$-$	$-$	$-$



	x	v_x	a_x
(e)	$+$	$-$	$+$



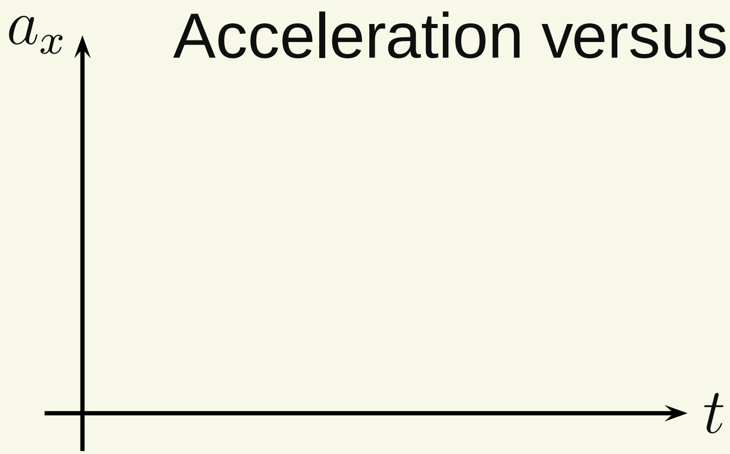
Constant Acceleration

For a constant acceleration:

Constant Acceleration

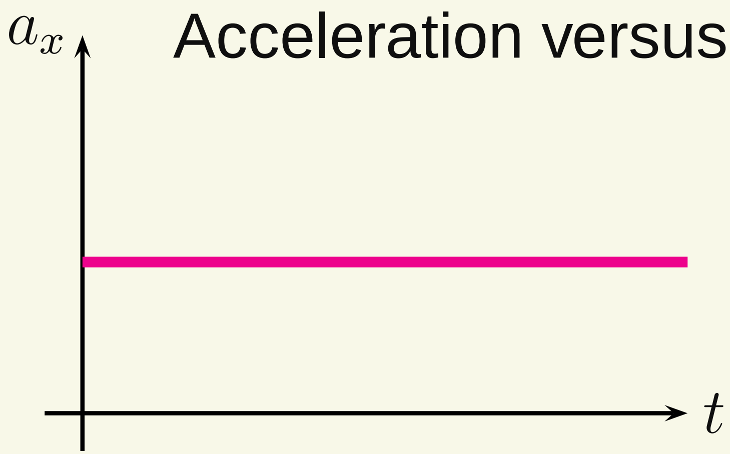
For a constant acceleration:

Acceleration versus time



Constant Acceleration

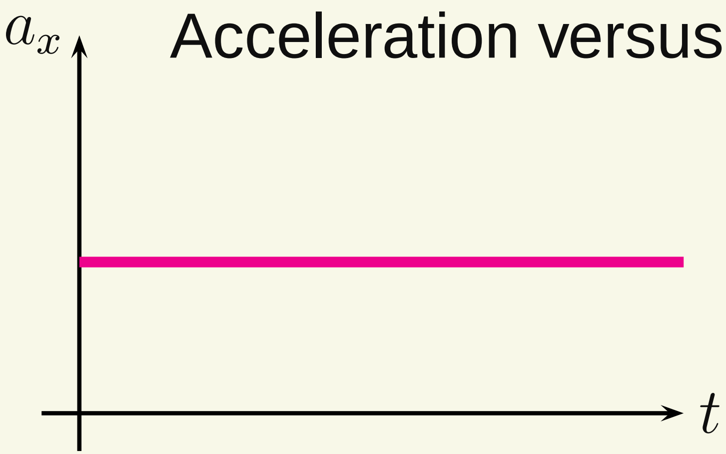
For a constant acceleration:



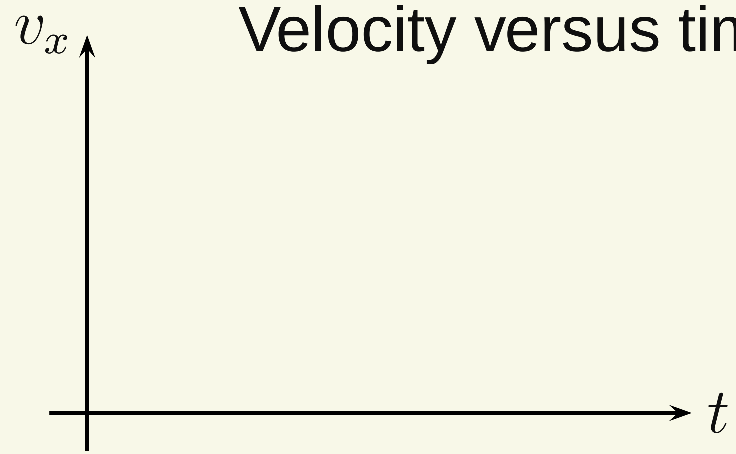
Acceleration versus time

For a constant acceleration:

Acceleration versus time

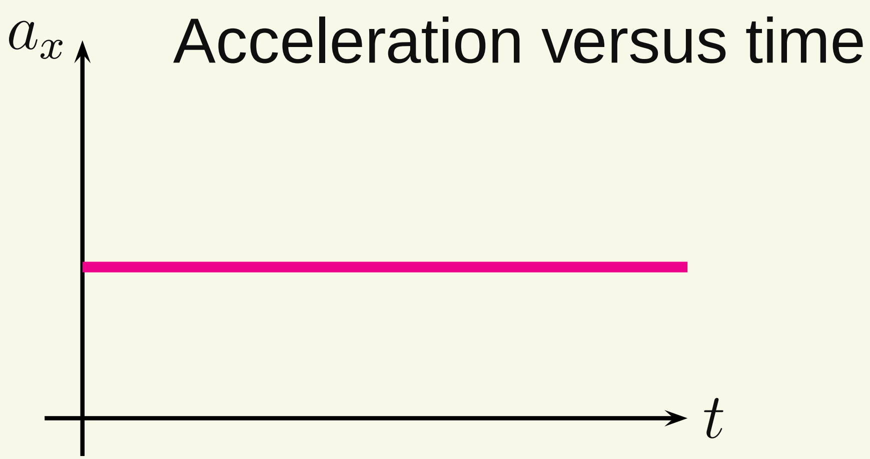


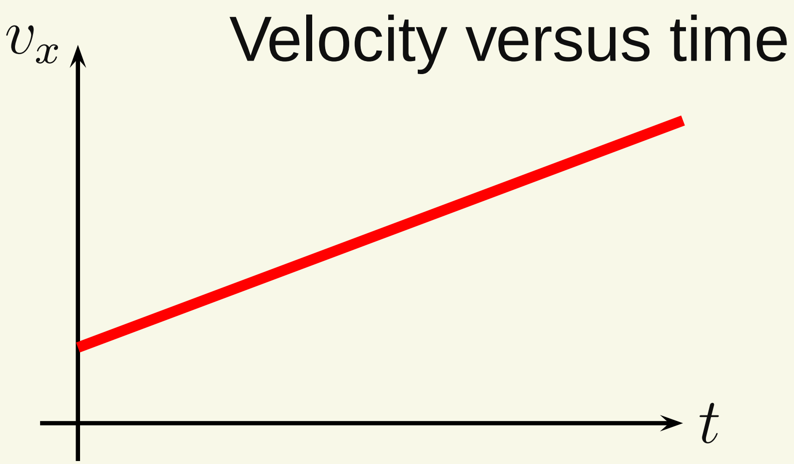
Velocity versus time



Constant Acceleration

For a constant acceleration:

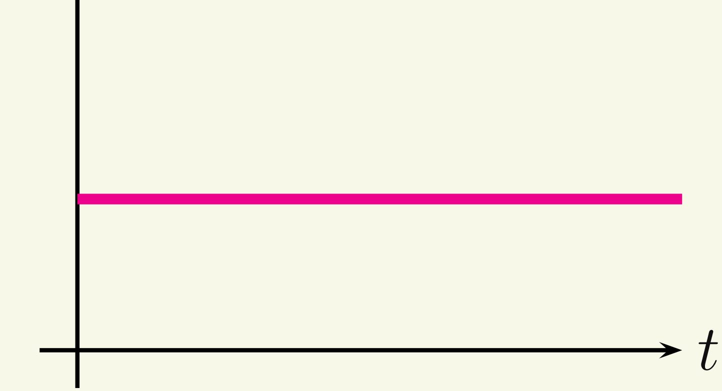




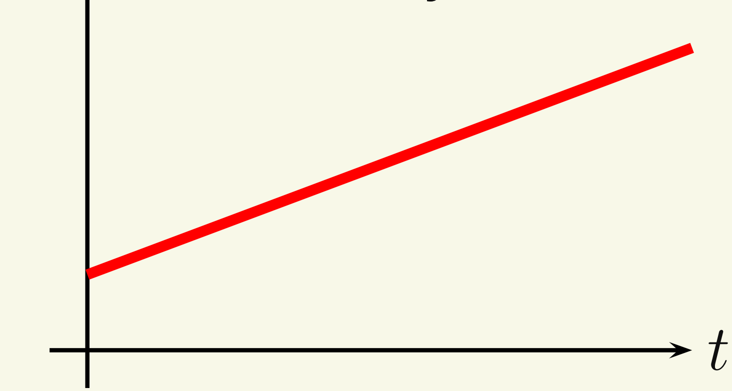
Constant Acceleration

For a constant acceleration:

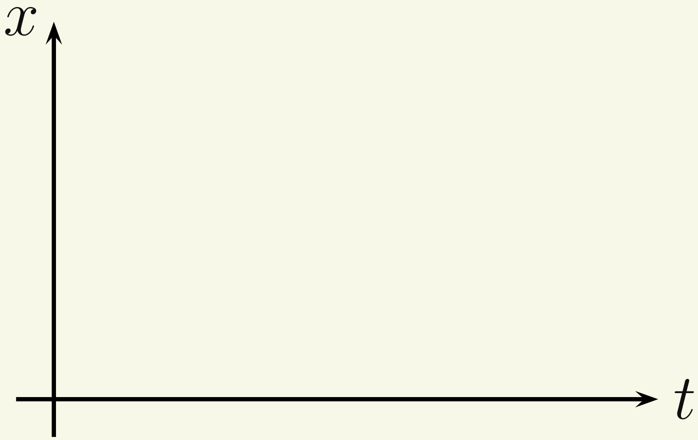
Acceleration versus time



Velocity versus time

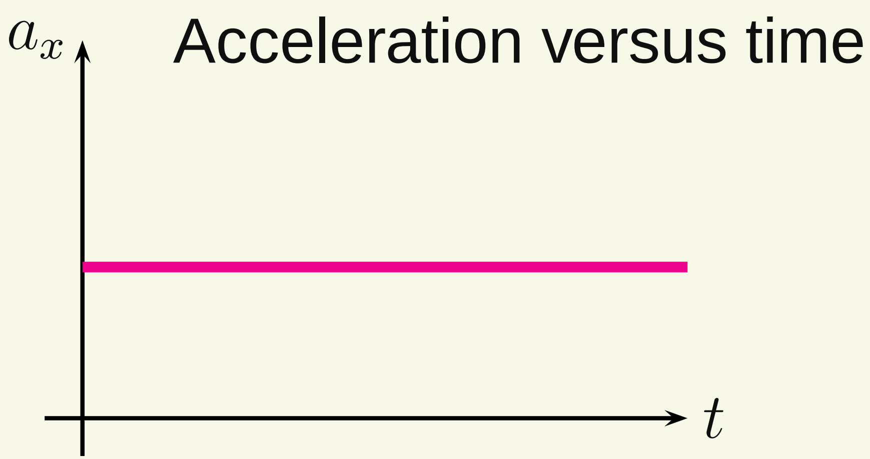


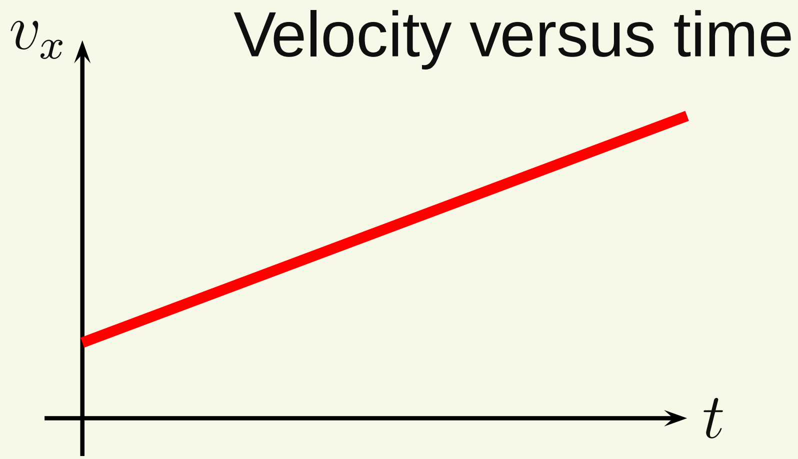
Position versus time

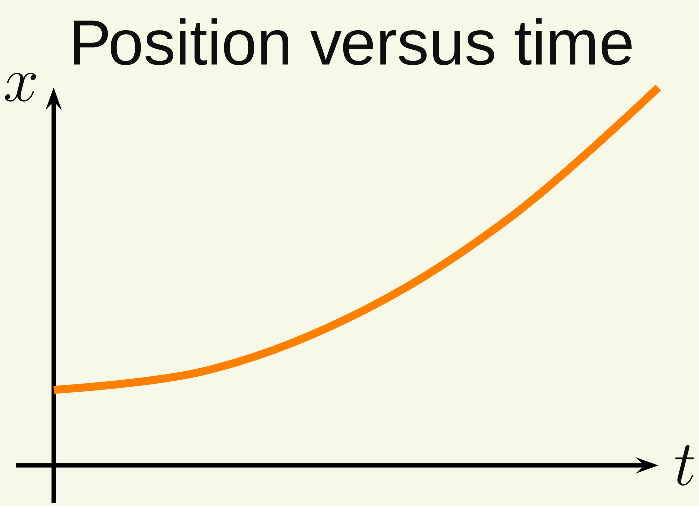


Constant Acceleration

For a constant acceleration:

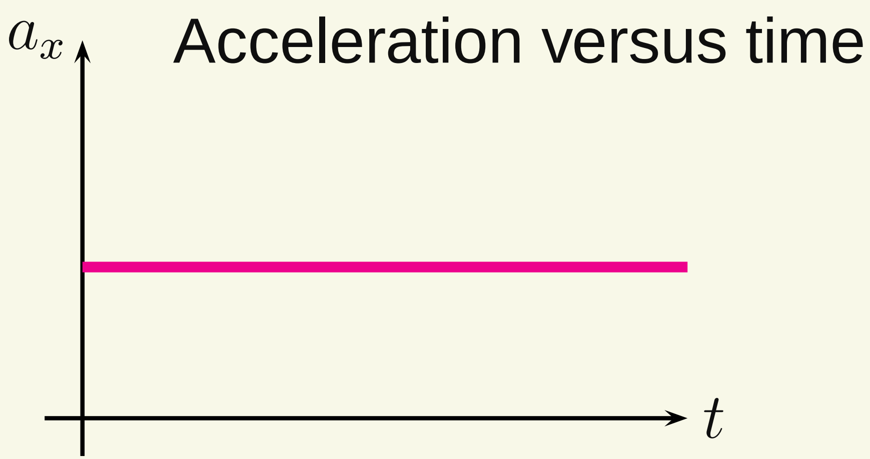


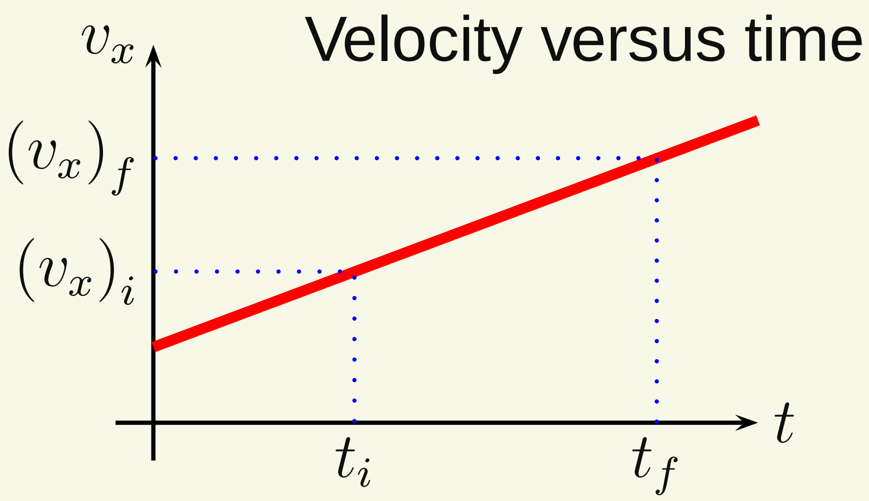


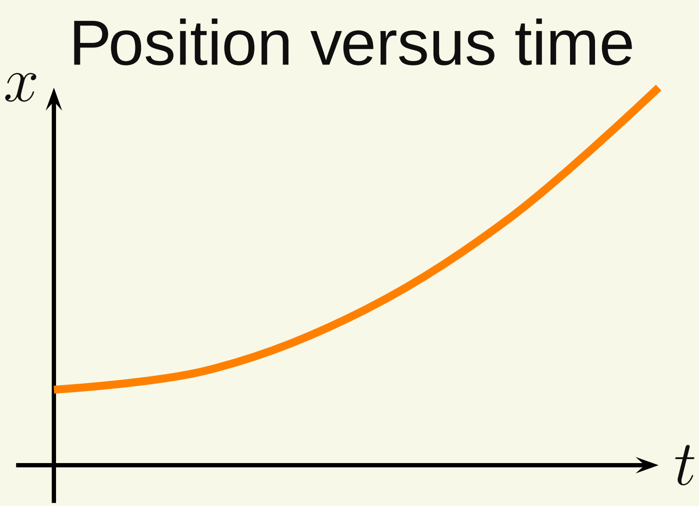


Constant Acceleration

For a constant acceleration:

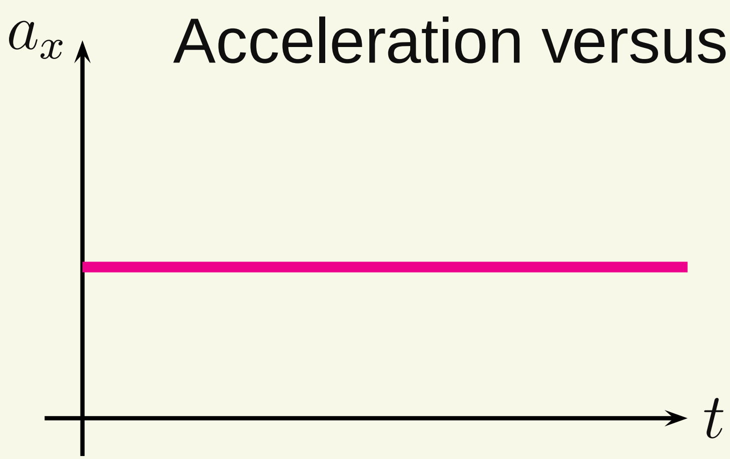




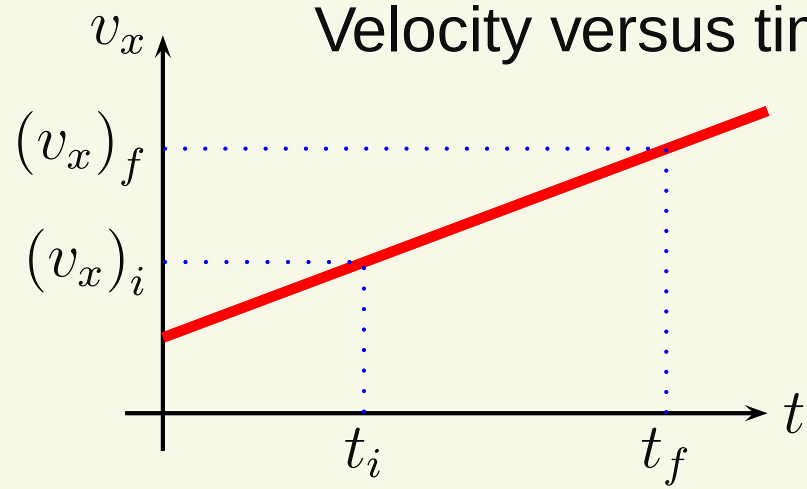


For a constant acceleration:

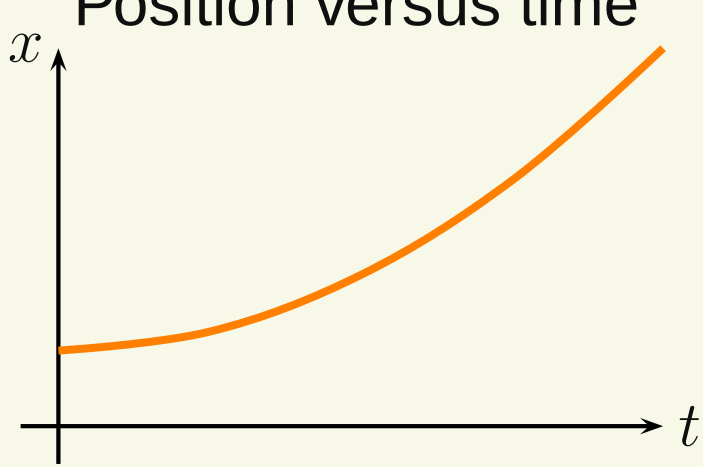
Acceleration versus time



Velocity versus time



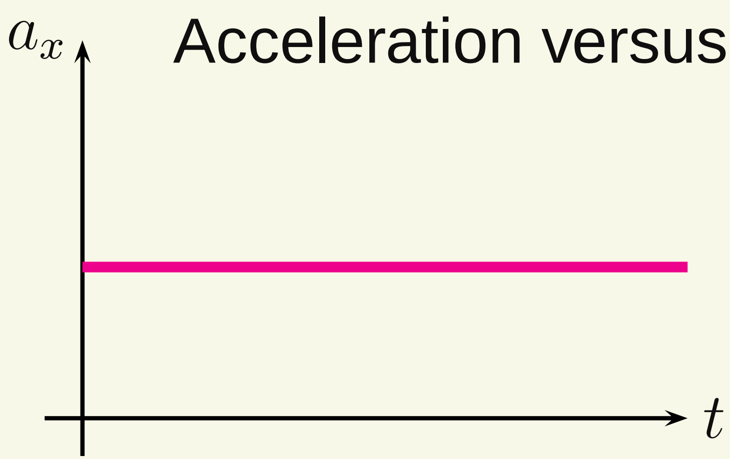
Position versus time



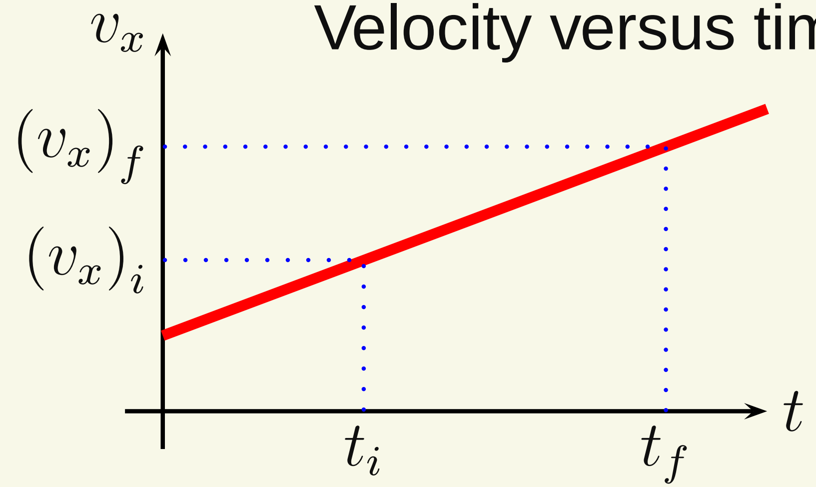
$$\boxed{(v_x)_f = (v_x)_i + a_x \Delta t}$$

For a constant acceleration:

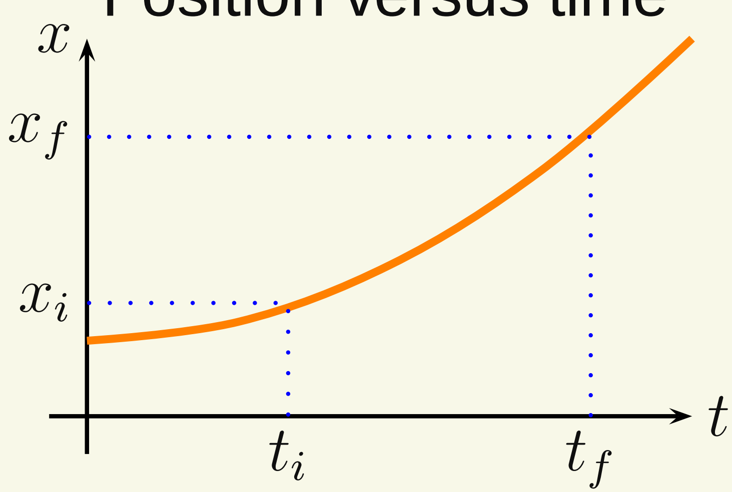
Acceleration versus time



Velocity versus time



Position versus time

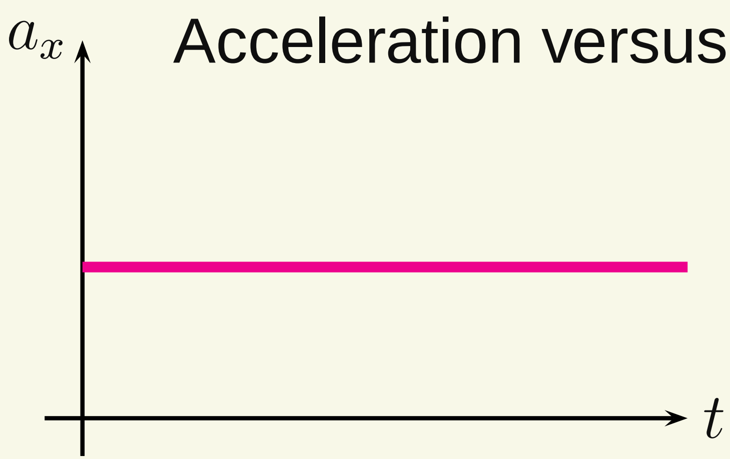


$$\boxed{(v_x)_f = (v_x)_i + a_x \Delta t}$$

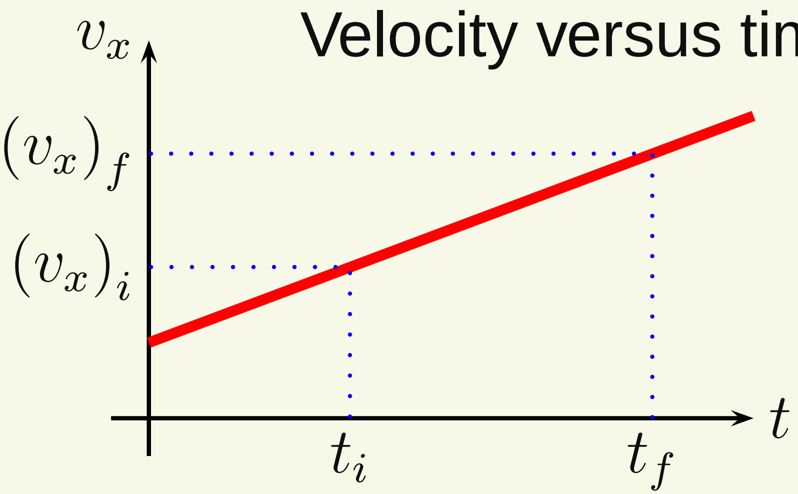
Constant Acceleration

For a constant acceleration:

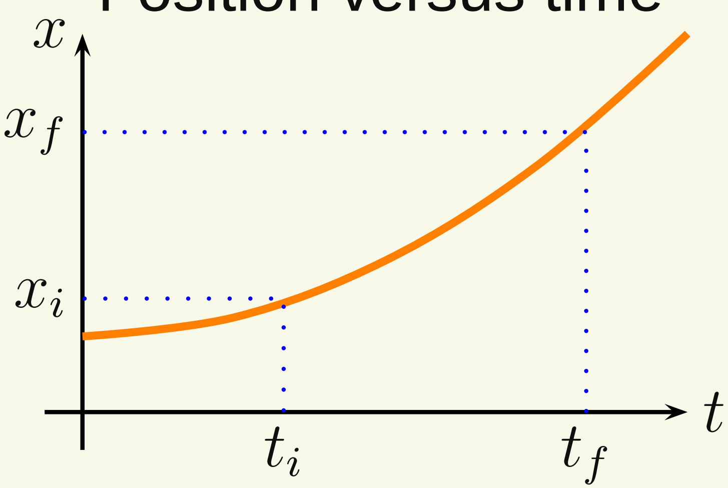
Acceleration versus time



Velocity versus time



Position versus time



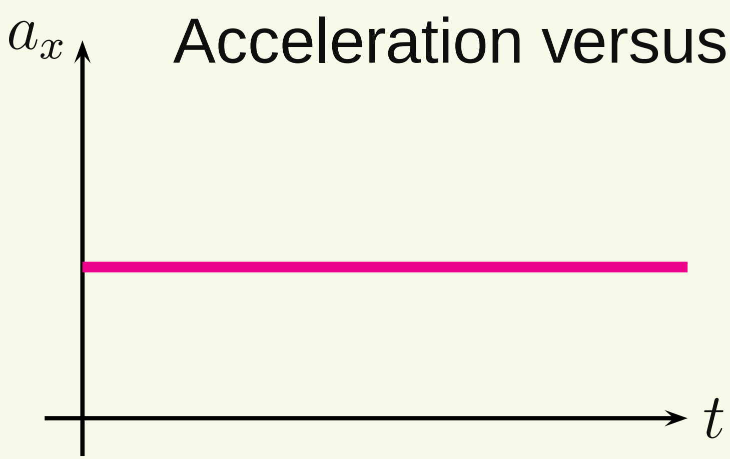
$$\boxed{(v_x)_f = (v_x)_i + a_x \Delta t}$$

$$\boxed{x_f = x_i + (v_x)_i \Delta t + \frac{1}{2} a_x (\Delta t)^2}$$

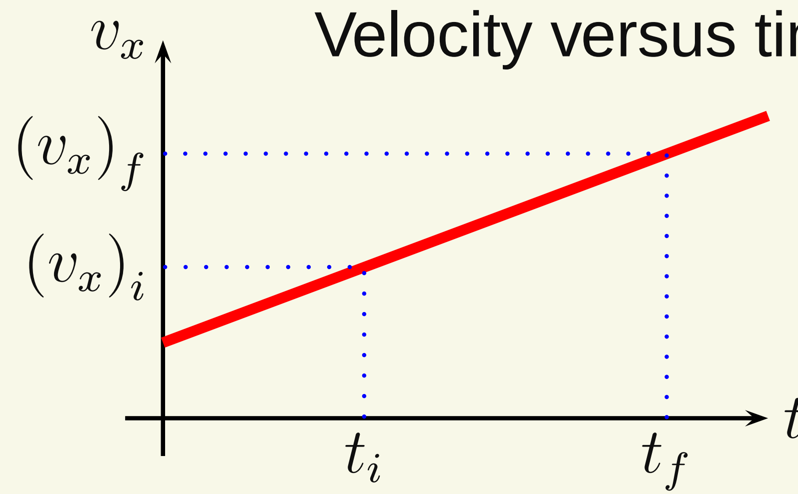
Constant Acceleration

For a constant acceleration:

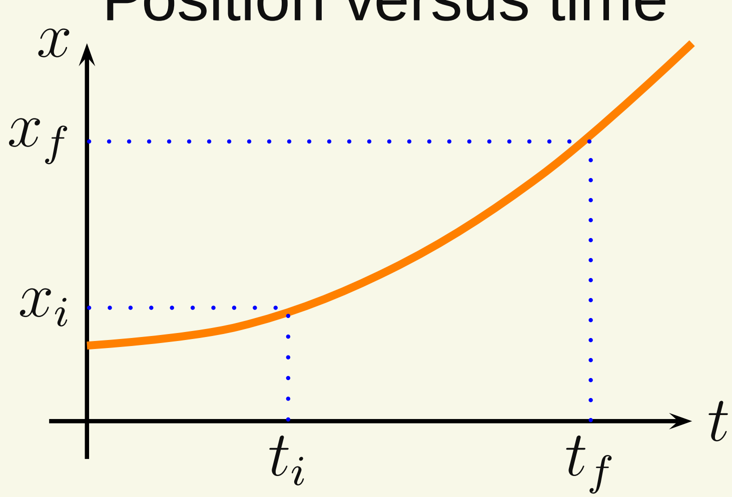
Acceleration versus time



Velocity versus time



Position versus time



$$\boxed{(v_x)_f = (v_x)_i + a_x \Delta t}$$

$$\boxed{x_f = x_i + (v_x)_i \Delta t + \frac{1}{2} a_x (\Delta t)^2}$$

$$\boxed{(v_x)_f^2 = (v_x)_i^2 + 2 a_x \Delta x}$$

$\longleftarrow$ From Algebra

Example

$$\boxed{x_f = x_i + (v_x)_i\,\Delta t + \frac{1}{2}a_x\,(\Delta t)^2}$$

$$\boxed{(v_x)_f = (v_x)_i + a_x\Delta t}$$

$$\boxed{(v_x)_f^2 = (v_x)_i^2 + 2a_x\Delta x}$$

Example: A car is traveling on a straight road with a speed of $30.0\,m/s$ when the driver hits the brakes causing a constant deceleration of $2.5\,m/s^2$. How long does it take and how far does the car go while stopping?